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The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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Powder Metallurgy

Our interest in the potentialities of powder metallurgy was aroused by the examination of a patent specification where a process for making metal moulds from iron powder was described. The method utilises porous sintered blocks which are stated to be capable of being readily cut to shape and built up to form moulds. It appears that the thermal conductivity and the porosity can be controlled. It is fairly common knowledge that bearings have been made of porous bronze and that these are stated to be oil-less in operation.

Another phase of powder metallurgy is that articles made by sintering such materials are very compact and micro-examination fails to reveal any difference in structure from that of wrought materials. It appears from an article which appeared in "Stahl und Eisen" a few years ago that pressure is not essential for consolidation and in the case of iron, densities of 6.3 have been attained merely by heating loosely-piled powder in an atmosphere of hydrogen, which specific gravity could be raised to normal by forging the sintered mass. Naturally foundry thought will be concentrated on this notion of producing permanent moulds from porous iron blocks, and it is interesting to learn that the porosity is controlled either by heating the metallic oxides in reducing gases or by the inclusion with the metal powders of various salts such as oxalates or tartrates and the like. One patent specification we have seen refers to the mixing of iron oxide with iron powder, water and certain saponifying agents, to give a stiff paste and this is suitably shaped and cut and then immediately sintered in a reducing atmosphere to yield products of extremely high porosity.

An intriguing phase of this type of experiment is the possibility shown of producing engineering assemblies made from several types of metals. It may be thought that the production of metal powders would involve an initial cost so high as to render it *ultra vires* as a raw material. Yet in many cases, some of these very materials are to our personal knowledge a drug on the market.

We have in front of us a list of sixteen firms which supply metallic powders which range from cobalt to aluminium and cover probably a dozen or more elements. One of the largest British foundries is carrying out some explanatory tests on the application of various metallic powders to the surface of moulds and whilst negative results may be obtained, the field is certainly one worth investigating.

It must be confessed that there has grown up a considerable but scattered literature around powder metallurgy, and anybody going to the trouble of assembling this in book form would indeed confer a boon upon all those who like ourselves are anxious to place the potentialities of the new science in its proper perspective.

Lubrication and Lubricants

During this month an important conference will take place on the subject of lubrication and lubricants. It has been sponsored by the Institution of Mechanical Engineers, and about one hundred to one hundred and fifty Papers will be presented by experts from many different countries under one of four headings. The first and fourth, dealing respectively with journal and thrust bearings and with the properties and testing of lubricants, are self explanatory. The remaining two, on engine lubrication and on industrial applications, serve to show how vitally the maker of cast iron is concerned with this problem. It is a remarkable fact that practically every form of reciprocating engine works with a cast-iron cylinder or liner and a cast-iron piston ring. This applies equally to the steam engine, stationary and moving, land or marine, to the internal combustion engine, petrol or diesel, stationary or moving, land or marine, and in a measure to the aero engine. That in recent years such developments as the austenitic as opposed to the pearlitic iron have been made, as well as nitrided and plated surfaces, does not obscure the central fact. In these cases lubrication is a matter of cardinal importance, as are such processes as abrasive and corrosive wear. The section dealing with industrial applications covers points of such importance to the industry as gears and gear teeth, transmission chains, wire drawing, wire ropes, ball and roller bearings, textile spindles, the application of cutting fluids in machining operations. The amount of experimental work done both by private and public bodies on the wear of cast iron has in recent years reached considerable proportions and has in a large measure now reached its objective, although finality has by no means been reached. In this work this country has had a very considerable share.

C

Correspondence

We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Refresher Course for Steel Makers

To the Editor of The Foundry Trade Journal.

Sir,—Miss Eilen Wilkinson's recent suggestion to the Ministry of Labour that the older steel workers who are now getting back to production after long periods of idleness should be afforded opportunities of taking "refresher" courses, is one which is worthy of the most serious consideration.

As makers of special steels, it is particularly important that all our workers should have perfect judgment and confidence in their work. Like many other steel makers, we returned to production after a period of three years idleness between 1931 and 1934. When our works were re-opened a large number of our men who had spent the better part of their lives in our employ were re-engaged; immediately, however, we noticed that several of the furnace men were not so certain of themselves in the all-important process of flame control, slag conditions, etc. Many of the men themselves confessed the greatest surprise that after over thirty years' experience they had lost touch to such an extent in three years idleness.

Another instance of the upsetting effect of inactivity was the frequent occurrence of blistered hands amongst men who had used steel and iron bars as well as heavy tools for years, but whose hands had become tender during their enforced leisure. In our case it was at least three months before the men became re-acclimatised and everything moved with its accustomed precision.

The nation cannot afford to lose the collective experience of the old craftsmen in one of our greatest basic industries. Surely as so much depends on our steel workers at the present time, it is not unreasonable to hope that the Government will co-operate in allowing them the opportunity of finding their feet again by practical "refresher" courses.—Yours, etc.,

The Brymbo Steel Company, Limited,
Glyn M. Jones
(*Director*).

Brymbo Steel & Ingot Iron Works,
Nr. Wrexham.

October 4, 1937.

[Whilst thoroughly agreeing with Miss Wilkinson and Mr. Jones—as to the obvious desirability of refresher courses, we fail entirely to envisage in what direction the Government could help, as the creation of *practical* refresher courses is to our mind impractical.—Editor.]

Discussion on Lubrication and Lubricants

To the Editor of The Foundry Trade Journal.

Sir,—I should be grateful if you would draw the attention of your readers to the discussion on lubrication and lubricants which will be held from October 13 to 15. It has been found necessary, owing to the large numbers of applications for membership, to arrange for the discussion to be held in the Central Hall, Westminster, London, S.W.1. Some 140 Papers are to be presented by the Group Reporters, who include Prof. H. W. Swift, Mr. H. Ricardo, Mr. W. A. Stanier, Lt.-Col. S. J. M. Auld, Mr. E. A. Evans and Dr. H. J. Gough.

In conjunction with the discussion an Exhibition will be held at the Science Museum, South Kensington, S.W.7. The exhibits will include lubricants, bearings, applications of lubrication, filtration, testing and research, as well as an interesting series of exhibits from the Science Museum collections. The exhibition will remain open until October 31.

I should be grateful if you could further draw attention to the fact that the advance proofs of the Papers are now ready and that information about the discussion can be obtained from the Secretary, the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1.—Yours, etc.,

Magnus Mowat,
Secretry.

The Institution of Mechanical Engineers,
Storey's Gate, St. James's Park,
London, S.W.1.

October 4, 1937.

Wilkinson Memorial

To the Editor of The Foundry Trade Journal.

Sir,—My attention has been drawn by Mr. Arthur J. While to leading articles and correspondence in your issues of August 26 and September 23 on the condition of the John Wilkinson Monument at Lindale-in-Cartmel.

It may interest your readers to know that this Monument was threatened with destruction in 1914, and was only saved by the efforts of a local committee, prominent among whom was the late T. R. Wilson, of Lindale. The Monument was saved from the scrap-heap, and the site was purchased and conveyed to the Parish Council of Upper Allithwaite. I wrote a small pamphlet: "John Wilkinson, Ironmaster" (now out of print) to help the funds, but sufficient was not subscribed, the Great War intervening, to lay out the site properly and secure its maintenance in perpetuity. That opportunity has now occurred. Mr. While has given a good lead towards a fund for that and the renovation of the Monument; and I shall be glad to add my mite.

As regards Wilkinson's last resting place, I had it on the authority of Mr. Wilson that his coffin rests in ground since added to Lindale Churchyard (see my book, page 48). This confirms Mr. While's statement.

Yours, etc.,

H. W. Dickinson
(Jnt. Hon. Sec., The Newcomen Society for the Study of the History of Engineering and Technology).

Barn Field, Riddlesdown Road,
Purley, Surrey.

September 29, 1937.

Catalogue Received

Pig-Iron. We have received from the Ford Motor Company, Limited, Dagenham, Essex, a 58-page well-illustrated brochure, which not only gives data of their machine-cast foundry, basic and hematite pig-iron, but also much technical matter concerning moulding sand properties and control. Finally there is a very intelligently compiled list of definitions of technical terms for the practical foundryman. All of these are unreservedly accepted except those for blowholes and gas holes. Whilst two perfectly good definitions have been propounded, their acceptance would involve a separate nomenclature for ingots and castings. Blowholes in ingots are unlikely to arise from the ingot mould, *per se* which phenomenon is the gist of the Ford definition. Stressed throughout the book is the ability of this concern to accord metallurgical help to users. Photomicrographs taken from castings produced from this iron, and photographs of castings made by users of this iron, serve as illustrations.

Wheel Speed in Polishing

The last issue of "Grits and Grids," issued by Alfred Herbert, Limited, of Coventry, and the Norton Grinding Wheel Company, of Welwyn Garden City, Herts, contains a very interesting article on the "Effect of Wheel Speed on Polishing Performance," by W. Pettigrew.

Random Shots

It is interesting to learn from an American contemporary that foundrymen on that side of the Atlantic in general are not familiar with the term "fettling department." In answer to a query as to the meaning of the term, one reader says that: "I had supposed that ours was the only shop in the country where the term 'fettling' is used, and am much interested in your comment on it. Our steel plant was originally designed and erected under the supervision of men sent over by Sir Robert Hadfield from Sheffield, England. . . ." The word, of course, needs no explanation to English foundrymen, but its meaning can best be conveyed to American readers by reminding them that the Yorkshire woman probably still calls out a parting question to her schoolboy son, "Have you fettled your ears this morning?" "Marksman" also remembers quite vividly a maid in the home of his youth who used to show distinct signs of irritation every Friday afternoon because she had to "fettle the kitchen" for the week-end.

* * *

This is by no means the only word to be carried over to another country by the English workmen who went to erect or to start up new plant. There is a works in Decazeville in the Midi of France where the words "Go on" and "Stop" have been in constant use for the past hundred years. There is, moreover, a row of little English workmen's cottages outside the works, just as one would expect to see in Lancashire, and the name of the Englishman who started that steelworks was Wilkinson, brother of the John Wilkinson who is claiming the attention of foundrymen at the moment.

* * *

On the other hand, the "drag and cope" so familiarly used here is borrowed from America.

* * *

After reading all about Wilkinson in the Journal, "Marksman" has gone all historical, and when one dips into the bran tub of foundry history, one can hardly help drawing out a gun! This time it is news of a gun which has just been transferred to the Tower of London, a brass one with the distinction of being the only gun known to have been cast in the presence of a ruling sovereign. It is engraved with the following inscription:—

Cast in the presence of His Majesty,
October 5th, 1638.
John Browne made this peece.
Mountjoy Earl of Newport,
Mr. General of the Ordnance.

It has been placed in the White Tower, together with ten model cannon made by John Browne and Thomas Pitt, but, according to Charles Ffoulkes in "The Gun Founders of England," this new addition is undoubtedly the most important of all the guns made by John Browne.

* * *

Thomas Browne, father of John, was in a big way of business as a gun founder in the late 16th and early 17th centuries, owning foundries in Kent. During the years 1591 to 1609 he boasted that he had delivered 463 tons of iron ordnance to "certain persons." He was granted a monopoly for making iron and brass guns for the Navy, and was later given a pension of eighteenpence for life, which was continued after his death to his son John.

* * *

Thomas Pitt was less known than Browne, but he is described in a record dated 1535 as being "an exquisite gun maker." Evidently his was no mass production factory, but a small exclusive business.

"Marksman."

Institute of British Foundrymen

FIRST TECHNICAL MEETING OF SOUTH AFRICAN BRANCH

The first technical meeting of the South African Branch of the Institute of British Foundrymen was held at Johannesburg in August, Mr. T. Nimmo Dewar presiding. Two short Papers were presented by Lieut.-Col. W. J. Grose, entitled "Loam Moulding of a 5¾-ton Pot" and "A Note on Coring a 15-ft. Roller with a 16 in. dia. Core." These two Papers, with the ensuing discussion, are reproduced below.

LOAM MOULDING OF A 5¾-TON POT

It is sometimes held in the foundry industry that changes of recent years and theories which have been constantly advanced during that time have caused the disappearance of loam moulding. It is certainly a fact that the scarcity of loam moulders in South Africa has relegated this process to the background, and, furthermore, the cost factor in loam moulding is such that its use is considerably less than formerly. At the same time, it is generally agreed that this type of moulding is very safe, and the casting produced will bear comparison with that resulting from other methods.

The casting here discussed was produced by the loam method in the foundry of Wright, Boag & Company, Limited, and the accompanying illustration (Fig. 1) indicates the plant which was required for the job. The finished article represented the successful conclusion of a series of problems by experience, and some idea of the magnitude of the task is furnished by the fact that it was necessary to make approximately 12 tons of tackle in order to complete this 5¾-ton job.

The method used in producing the casting was determined by the specification of the pot, which was to be cast bottom-down, since it had been found that in previous pots cast bottom-up the metal in the bottom was unsatisfactory. It was further provided that no chaplets were to be used to separate the inside main core, while joints in the mould were to be avoided, as they had been found to cause cracks when former castings had been subject to great heat. All these factors had to be taken into consideration in determining the method employed to produce the casting.

Pattern Equipment

Before proceeding to create the equipment, it was necessary for the patternmaker to appreciate the difficulties that might arise in the foundry, and these were duly borne in mind. Thereafter the patternshop produced the following strickle boards:—One for the main body with a removable joint piece for setting the spout; one for strickling form for bottom of core; and one for extending the core to the top. The socket ring core was struck with the bottom corner rounded with a 3 in. rod to allow an even flow of metal at this point when in position, and overcome the possibilities of blowholes. This was the only face which had to be machined.

The foundry tackle used comprised the ordinary moulding tools, including the spindle with crosses or footstep socket with spindle arms. New tackle required included ring plates and spiders. The approximate weight of the material in all was in the neighbourhood of 12 tons. The following are details of the job:—A nitric pot or retort with a spout 5 ft. long from the centre at the bottom with a core 2½ in. dia., the inside diameter of the pot being 6 ft. 9 in. by 6 ft. 8 in. deep, metal on the sides 1½ in. thick, and bottom 3 in. thick. The metal on the spout was 2½ in. thick.

It was decided to build the body *in situ* to eliminate jointing. It will be appreciated that this entailed moving a weight of some 20 tons, and that it was necessary to shift the body to the stove to be dried. This necessitated making a bottom plate about 3¾ in. thick, involving the weight of 5 tons, the plate being passed over the spindle on to the floor. Brickwork was built up to a height of 12 in. from the bottom of the mould, every precaution being taken to ensure the rapid escape of the gases during the casting.

The pattern of the spout was made of solid wood, jointed horizontally for setting at an

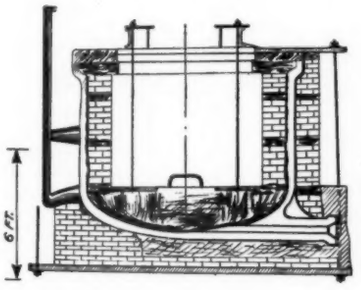


Fig. 1.—Tackle Required for Loam Moulding a 5¾-ton Pot.

angle, and divided into four sections to facilitate the drawing of the pattern when the mould was dry. At the end of the spout, on top, a separate core 18 in. square by 12 in. deep was placed to enable the spout 2½ in. dia. core to be secured into position. Hence to the top of the body the walls were built up approximately 12 in. thick with three thin reinforcing cast-iron rings. Thereafter the inside was strickled to a finished face and dried.

Runners and Gates

The gates and runners, 3 in. in diameter, were built into the brickwork. It was, however, subsequently found that it would have been preferable to have made the runners 4 in. in diameter. Owing to the size and weight of

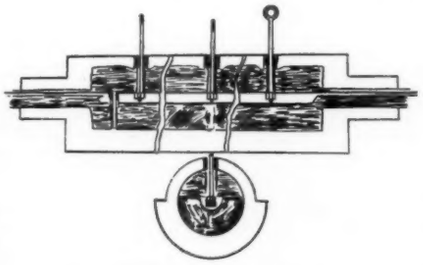


Fig. 2.—Roller, 12½ ft. long, with Trunnions 18 in. long.

the inside core, and for the sake of accuracy, a concave base to the shape of the core was built in brickwork 22 in. deep, on a plate similar to the plate of the body, but lighter, weighing approximately three tons. The bottom of the core was now made inside this form, supported by a spider strong enough to support a lift of eight tons, which was the estimated weight of the inside core. The bottom section of the core under the spider was filled with ashes for venting.

This inside spider, weighing about two tons, had four lifting handles 1½ in. dia., and four 1½ in. dia. nuts cast in the metal to connect and support the whole core to the top plate with 1½ in. dia. rods. The walls of the core, 3½ ft. from the top, were 12 in. thick, leaving the inside open. A vertical row of soft loam bricks ensured freedom to contract, being broken after casting. Thereafter, the false base with the core was then dried for one night, the core lifted, and the bottom nailed and returned to the stove for the complete drying.

Core-Setting

It was obvious that the success of this job depended on the accurate core setting, which was achieved as follows:—

A hole large enough to accommodate the mould was dug to a depth of 8 ft., the body then being lowered into place. Then eight blocks of wood 12 in. by 18 in., equal to the thickness of the metal, were placed on the bottom of the mould, and on to them the core was lowered and supported, care being taken to check the thickness of the metal at the sides. The core, being slung from four points, was found to be slightly out of alignment with the mould, and it was impossible therefore to set it correctly until it was lifted flush with the top, levelled off true to the joint of the mould, then re-lowered into its place.

The socket ring core, 5 ft. deep and 7 ft. 4 in. dia., was next placed into position, and on top of this came the top cover plate. Two heavy section girders were now placed across the cover plate, and from these four 1½-in. bolts were connected to the spider by screwing into the nuts already cast in. The whole of the core was now supported by the spider. The tie bolts from the lugs on the bottom plate of the body were connected into position and the space round the rods was filled in with sand, with the exception of a space left open over the end of the spout. Then the stakes were knocked in at the ends of the top plate stake lugs, and the inner core secured to the top plate was now lifted.

The spout core was now secured into position with special chaplets, the wooden blocks above referred to removed, clays placed to check thickness, the core was lowered and lifted, the clays removed, and thereafter the core was lowered finally into place. The opening at the spout was thereafter filled, allowing for a small riser or vent to overcome the possibility of an airlock at this point. Tie bolts were connected to the top plate, with 30 tons weight on top of cross girders; about twelve 1¼-ft. risers were used to complete the job.

The following figures may be of interest:—Weight of cast-iron tackle was 12 tons; cast-iron for casting—8 tons; charge was made up of 5 parts hematite scrap, 3 parts Iscor pig-iron and 2 parts grey iron scrap; patternmaking time—75 hours and moulding time—525 hours.

A NOTE ON CORING A 15-FT. ROLLER WITH A 16-IN. DIA. CORE

The roller illustrated in Fig. 2 is 12½ ft. in length with trunnions at each end 18 in. long with 12 in. dia. and 6-in. core. The main core was 16 in dia. and 12 ft. long. The roller was to be used for corrugated iron and it was specified that no chaplets should be employed to support the core, since the roller was to be machined into longitudinal corrugations.

The core iron, 4 in. sq. in section, was reduced at the ends to half the thickness to allow for venting with toes and horns 9 in. apart. It will be realised that the iron made to suit this core could not be relied upon to prevent the core moving when casting. To overcome this difficulty, three 1-in. nuts equally spaced were cast into the iron and into these nuts eyebolts were screwed, to lift the core from the half corebox and place it in the mould.

A solid half corebox, the top half of the core being strickled, was used. Pieces of 1¼-in. pipe were placed in the core on top of the nuts to prevent the sand fouling the nuts when changing the bolts.

The mould being now ready, blocks of wood 2¾ in. thick were placed to support the core in its correct position, and the core now set, the eyebolts were replaced with bolts screwed at both ends. Over these bolts were placed cores of 2½ in. dia., equal to the thickness of the metal, and the mould was closed up with the top box and secured to the core by these bolts. This prevented the core from either lifting or dropping. It was necessary to avoid any undue strain in screwing into place.

The whole was now lifted, wood blocks removed, and the mould finally closed, but since the core had butt-ends, unusual contraction was anticipated, so 1 in. was taken off the 12 ft. length. The castings produced were correct as to length and metal thickness, and free from blowholes. Finally, the holes formed by the core to protect the bolts were then tapped, plugged and finished off.

DISCUSSION

Core Inspection of Nitric-Acid Pot

Mr. Boag indicated the enormous amount of tackle required for the job, pointing out that only those who were intimate with the work realised the trouble taken by foundrymen in the production of unusual jobs.

Mr. Tonge, congratulating Colonel Grose, pointed out that half the trouble in the foundry was to know how to run a job and where to put the risers, and that Colonel Grose had illustrated a very expensive piece of work. The only criticism he could offer was that it might have had a peephole in the side to enable inspection of the core.

Colonel Grose, agreeing, pointed out that without some method of checking up, it was just a matter of luck that all was correct.

Mr. Bragg said that Colonel Grose's description was very interesting, and illustrated that the time and tackle involved in jobs of this nature certainly prevented profit. In reply to a query from Colonel Grose as to why ingot moulds cracked, he suggested that this was probably due to gas holes in the joint. He thought that the job might have been jointed and sealed in closing.

Core Making Problems

Mr. Bragg inquired how the core was prevented from rising.

The Lecturer said that this was done by the bolts being secured to the top box to prevent either lifting or dropping.

Mr. Mackay asked if there was danger of metal running into the core through the lengths of piping covering the bolts.

In reply, Colonel Grose said there was no danger, owing to the plug cores sealing them, and, answering a question by Mr. Holdsworth, he said that the casting had to be machined on the bottom half of the roller only. The trunnions at each end had to be machined to 12 in. diameter.

Mr. Holdsworth thought that the roller might have been cast on end by the following method: The core could have been struck on a 4 ft. barrel. He had cast a roller 14 ft. by 2 ft. dia. by this means.

The Lecturer questioned whether a 4 ft. barrel would have been rigid enough.

Mr. Holdsworth said it could be done quite easily on a 4 ft. barrel provided the core was well made with straw rope and cast iron arms on the pipe to support the core.

Mr. Mildren thought that the core could have been made with a frame using a top and bottom strickle and made in the floor.

The Lecturer concurred that this method could have been followed, and, replying to Mr. Mackay, he said that the matter of contraction had been decided by guesswork. He had calculated from the contraction on two pillars 24 ft. long with 3-ft. square flanges, 4 in. thick, which his firm had cast for Iscor; the standard contraction for iron less 1¼ in. was used, and the flanges had come out 4⅛ in. thick, involving an error of ¼ in. on 24 ft.

Mr. du Plessis asked whether any rule other than guesswork based on experience could be laid down.

The Colonel pointed out the main factors which had to be taken into consideration, such as atmospheric conditions in cooling; hardness of core; mixture of metal; temperature of casting; the fact that one moulder rammed harder than another; and the design of the job.

Mr. du Plessis said that they had cast a 12-in. stick of aluminium which contracted $\frac{3}{16}$ in., but that a cast 7 ft. long had contracted only ⅜ in. instead of 1¾ in. as might have been expected.

Colonel Grose pointed out the difficulties always encountered in casting aluminium.

A vote of thanks to the lecturer concluded the proceedings.

Catalogues Received

Volume Fans. We have received from Keith Blackman, Limited, of 27, Farringdon Avenue, London, E.C.4, a new catalogue of their standard type (No. VI) which supplies thousands of figures relative to electric-fan characteristics. Its extreme usefulness is obvious, for special consideration has been given to quietness in operation, the exhausting of inflammable fumes, dust-laden atmospheres and a variety of special applications. This catalogue is of the type which is well worth while keeping by one.

Soda Ash. We have seldom received a piece of publicity designed mainly for the foundry industry, which is more informative, better illustrated and more practical than one bearing the title "Sodium Carbonate for Metal Refining" issued in connection with the Foundry Exhibition at Olympia by Imperial Chemical Industries, Limited, of Imperial Chemical House, Millbank, London, S.W.1. It runs to 60 pages, is particularly comprehensive and covers even such phases as the influence of sodium carbonate on refractories, and the preparation of linings for ladles in which the desulphurisation is carried out. This brochure also includes some notes about the application of sodium carbonate to blast-furnace practice, a subject of indirect but very real interest to foundrymen as an added production figure of 20 per cent., associated with a coke reduction of 15 per cent. is claimed. Another aspect included is that of refining non-ferrous metals. There is still a phase of this subject which still requires to be dealt with and that is the relation of the soda ash process to the enamelling shop. This brochure is available to our readers, and we advise those who have not yet received a copy to make early application.

(*Concluded from next column.*)

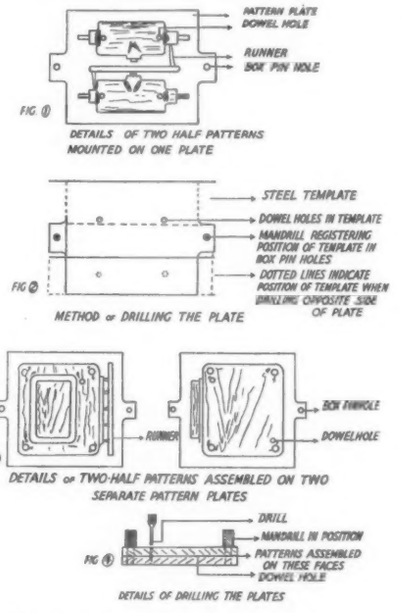
When it is necessary to assemble the two halves of a pattern upon two separate pattern-plates, the procedure shown in Fig. 3 may be adopted. The two pattern-plates, after being machined flat, are drilled to accommodate the registering pins of the moulding box. After marking the faces upon which the half patterns are to be assembled, one half pattern can be placed in its correct position, with provision left for runners, etc., and the dowel holes continued into and through the plate. The two plates are then placed face to face, as shown in Fig. 4, and registered by mandrels through the box pin holes; the dowel holes are continued through the bottom plate, thus giving two plates drilled correctly about the box-pin centres.

Centring of Pattern-Plates

By J. C. Wall.

The article by Mr. James Timbrell* gave some interesting details of methods of correctly centring patterns upon plates for the production of moulds, by machine moulding. Readers of the Journal may be interested in an alternative method for drilling the plate correctly to ensure a perfectly finished casting. This method is recognised by patternmakers as being a speedy and foolproof method for assembling patterns of any description upon wood or metal plates.

When two half-patterns are to be mounted on one plate, as outlined in Fig. 1, for the production of two castings for a moulding box, the following procedure may be adopted. A ½ in. thick steel plate (called the template) is required to cover slightly more than half of the pattern-plates, as shown in Fig. 1. Two holes are drilled to suit the existing "pin" holes in the moulding


PATTERN PLATE DOWEL HOLE
RUNNER
BOX PIN HOLE
FIG. 1
DETAILS OF TWO HALF PATTERNS MOUNTED ON ONE PLATE
STEEL TEMPLATE
DOWEL HOLES IN TEMPLATE
MANDRILL REGISTERING POSITION OF TEMPLATE IN BOX PIN HOLES
DOTTED LINES INDICATE POSITION OF TEMPLATE WHEN DRILLING OPPOSITE SIDE OF PLATE
FIG. 2
METHOD OF DRILLING THE PLATE
BOX PINHOLE
RUNNER
DOWELHOLE
FIG. 3
DETAILS OF TWO HALF PATTERNS ASSEMBLED ON TWO SEPARATE PATTERN PLATES
DRILL
MANDRILL IN POSITION
PATTERNS ASSEMBLED ON THESE FACES
DOWEL HOLE
FIG. 4
DETAILS OF DRILLING THE PLATES

box. This template would be immediately available in a modern pattern-shop.

Assuming that the pattern is jointed across the centre-line, finished and dowelled together with steel dowels, one half of the pattern is clamped in position on the template, which is in turn registered correctly upon the pattern-plate by steel mandrels inserted through the box "pin" holes (Fig. 2). The dowel holes which are in the pattern are continued into and through the pattern-plate. The pattern is then removed, and the template turned over on to the opposite side of the plate; the holes in the template are continued into and through the plate. Thus the dowel holes are correctly registered on a central position about the box-pin centres.

The patterns are assembled and screwed in position, any runners or risers that may be required are added, and the job is ready to be sent into the foundry for production.

This method saves much time that may be taken in setting up the plate and marking the positions off with a scribing-block, and it is not every patternshop that is equipped with elaborate methods for marking off such a job as this, so it can be appreciated that the method described can be adapted to suit any particular job that presents itself in patternmaking.

(*Concluded in previous column.*)

* Foundry Trade Journal, September 9, 1937, p. 193.

Cupro-Berylliums

THEIR SIGNIFICANCE AND FUTURE IN THE NON-FERROUS FOUNDRY*

By DR. J. LAISSUS and L. PERSOZ

In recent times beryilium and its alloys have claimed some attention from scientists and metallurgists both in France and in other countries. Because of the technical improvements in the production of beryllium, this metal is no longer a laboratory curiosity. It is now made in large quantities, and because of this a wide range of alloys is now available.

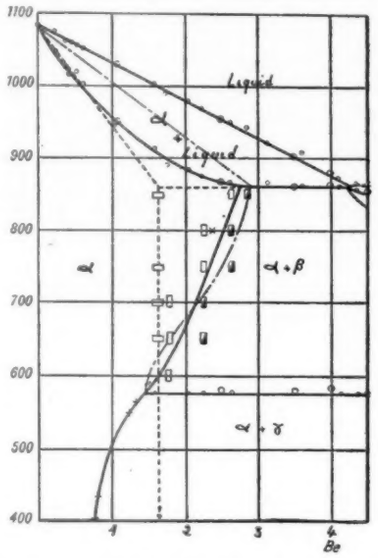


Fig. 1.—Copper-Beryllium Equilibrium Diagram up to 4 per cent. Be.

The dotted line is according to Oesterheld and Bassel; the dash and dotted line to Masing and Dahl and the full line to Borchers.

Amongst these, the alloys of copper and beryllium have, unquestionably, received the most attention. Their properties are particularly interesting and characteristic, and, in spite of their relatively high price, are finding employment for certain jobs, particularly in America. In France copper-beryllium alloys are beginning to attract the attention of manufacturers, and it is confidently expected that their use will be widespread in the relatively near future.

It should therefore be useful to set out some of the more recent results of research appertaining to these alloys. If copper-beryllium alloys seem, as will be shown, capable of being used in a large number of industries, that of the non-ferrous foundry is certainly outstanding. Here there is to be found a field of activity so important that already it is possible to point to several successes.[1] [2]

It should be pointed out that beryllium is not really a metallurgical novelty. The Egyptians used it more than a thousand years before the Christian era for the manufacture of certain types of stone-cutting tools. This has been proved by Mr. Ulivi Planta, director of the Egyptological Museum of Brussels, from a chemical analysis of such tools.

It is proposed in what follows to deal with copper-beryllium alloys of the commercial type containing up to a maximum of about 3 per cent. of beryllium. Copper-beryllium alloys of high Be content are only used as stock alloys.

The following aspects have in turn been examined:—

(1) The copper-beryllium system.
(2) Mechanism of the ageing of the alloys.
(3) Commercial compositions.
(4) Heat-treatment.
(5) Mechanical properties.
(6) Special properties and characteristics.
(7) Uses.
(8) Copper-beryllium alloys with cobalt.
(9) General conclusions.

Copper-Beryllium System

The copper-beryllium equilibrium diagram covering up to 30 per cent. of beryliium was elaborated by Oesterheld[3] in 1916. This first diagram showed an α solid solution containing up to a maximum of 1.65 per cent. of beryllium, this content remaining constant no matter what the increase of temperature was. In this case, the area of the solid solution was limited by the vertical line (Fig. 1). In addition to the studies of Bassett and Corson, reference should be made to the important contribution made by Masing and Dahl who, in 1927, elaborated a new diagram (Figs. 1 and 2). They introduced important modifications, notably from the point of view of the *solidus* limiting the area of the α solid solution, and gave evidence of a variable curve of solubility of the beryllium in the copper. Thus, as is shown in the diagram, copper can dissolve at the solidification temperature (855 deg. C.) up to 2.8 per cent. of beryllium, which forms an α solid solution. When the temperature decreases, the solubility is decreased and it forms a β solid solution which contains more beryllium and which is very hard. This crystal is only stable above 578 deg. C., and below this temperature it separates into α and γ. At the temperature of the separation of the β crystal, copper can still absorb 1.5 per cent. of beryllium in the form of an α solid solution. At much lower temperatures, the α solid solution which is of great hardness separates out, and the solubility of beryllium naturally decreases until there is no more than about 0.75 per cent. of dissolved beryllium at 400 deg. C. The alloys containing 2.8 to 4.2 per cent. of beryllium form at the point of solidification α and β solid solution; the alloys containing 4.2 to 10.5 per cent. of beryllium form nothing other than β solid solution which dissipates itself below 578 deg. C. to form α and γ solid solution, forming a eutectoid (α + γ) for a content of 6 per cent. of beryllium. Borchers, dealing with this phase in his work in 1932, published a fresh diagram taking into account as much as 33 per cent. of beryllium.[5] Fig. 3 gives the general structure of this diagram and Figs. 1 and 4 show details of certain particularly interesting fields.

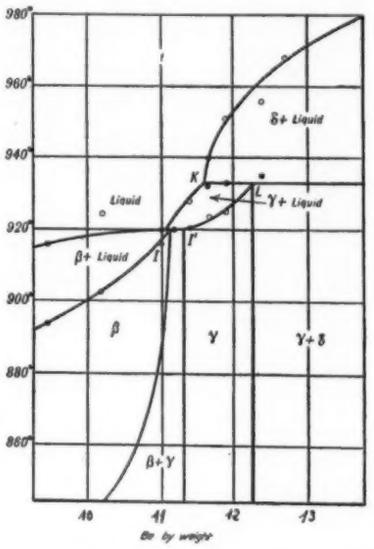


Fig. 4.—Partial Diagram showing the Structure of the Alloys of Copper-Beryllium containing between 9 and 14 per cent. of Be (Borchers, 1932).

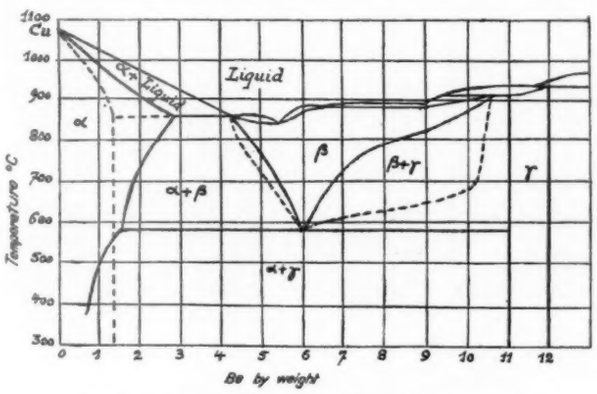


Fig. 2.—Copper-Beryllium Diagram according to Masing and Dahl (1927).

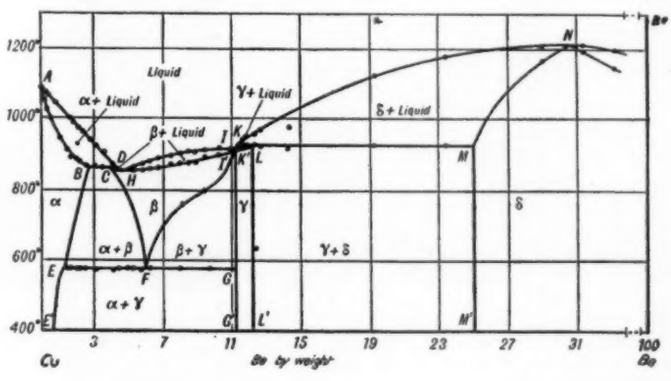


Fig. 3.—Copper-Beryllium Diagram (Borchers, 1932).

* Paper read before the International Foundry Congress in Paris.

Borchers' diagram modified the curve of solubility separating the fields α and $\alpha + \beta$. He also changed the form of the solidus in the area α and materially simplified the liquidus-solidus of the β area. As to the existence of a Cu_2Be compound, the author seriously questions this.

Microscopic examination of the structure of the copper-beryllium alloys at different beryllium contents clearly shows up the separation of the fields of the diagram. Fig. 5, originated by Masing and Dahl[4] shows the structure of a copper-beryllium alloy containing 1.46 per cent. of Be, annealed at 400 deg. C. The high magnification (× 1,900) clearly shows up the polyhedra of the α solid solution and chiefly in the boundaries of these polyhedra, particles of γ crystals.

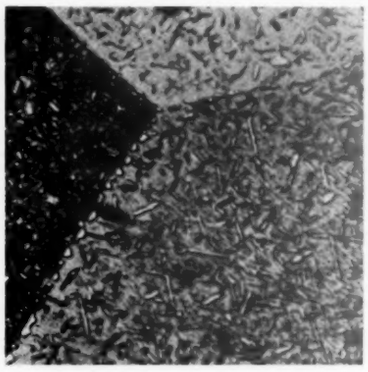


Fig. 5.—Cu-Be Alloy with 1.46 per cent. of Be Heat-treated at 400 deg. C. Etched Ammoniacal Solution of $CuSo_4$ × 1,900 (Masing and Dahl).

The authors also have examined many samples of copper-beryllium alloys and Figs. 6 to 9 show the structures of such alloys containing increasing quantities of Be. These samples were all annealed under the same conditions for 5 hours at 400 deg. C. Figs. 6 and 7 show up the structures of the two phases exhibited by alloys containing 2.2 and 9.35 per cent. of Be corresponding respectively to the two ends of the $\alpha + \gamma$ range.

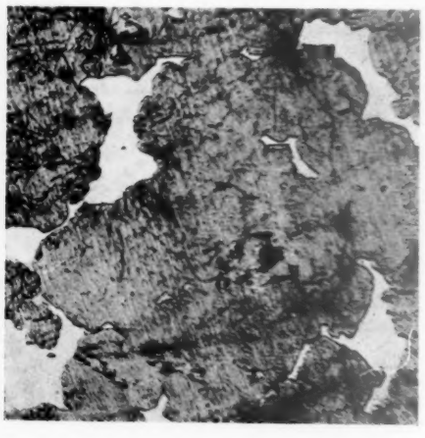


Fig. 8.—Cu-Be Alloy with 23.15 per cent. Be. Annealed at 825 deg. C. for 2 hrs. Etched dilute HCl × 270.

Fig. 8 refers to a sample containing 23.15 per cent. of Be, and shows the δ phase with residual areas of γ. Finally, Fig. 9 shows the characteristic constituents in a copper-beryllium alloy containing 78.6 per cent. of Be. This part of the diagram not yet having been developed, it is impossible to put forward a hypothesis as to the exact nature of the constituents. The large shaded areas seem to correspond to a structural constituent similar to that met with in β brasses. The structure clearly appears to be a compound, seeming to confirm the fragility of the alloy.

Mechanism of the Ageing of Copper-Beryllium Alloys

A solubility which decreases when the temperature is lowered constitutes the primary condition to which a metallic addition should respond to bring about an improvement in alloys by quenching following reheating. In fact, one observes with both alloys of copper and of beryllium phenomena of extremely well-marked hardening. As is indicated by the constitutional diagram, the ameliorative property is chiefly shown by alloys of copper and beryllium containing 1.5 to 4.0 per cent. of Be. Increases in hardness which can be attained by ageing are chiefly shown by alloys containing 2.4 to 3.5 per cent. of Be. With higher percentages, higher hardness values can be obtained but the inherent hardness is already well marked.

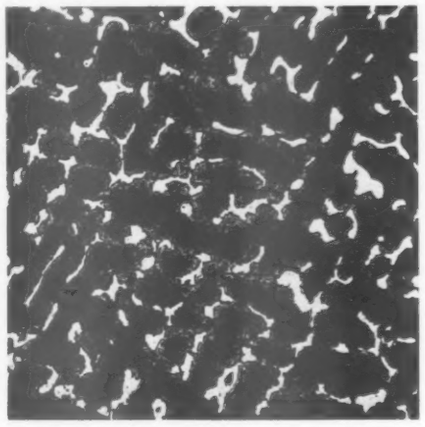


Fig. 6.—Cu-Be Alloy with 2.2 per cent. Be. Annealed at 400 deg. C. for 5 hrs. Etched Ammoniacal Solution of $CuSo_4$ × 75.

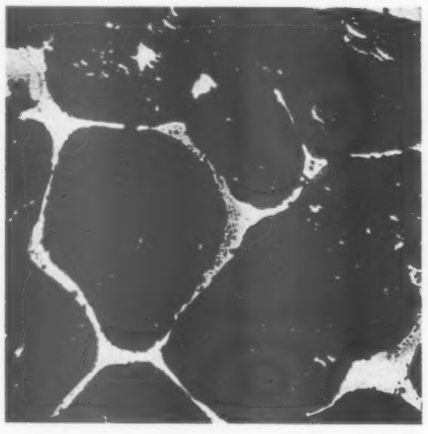


Fig. 9.—Cu-Be Alloy with 78.60 per cent. Be Annealed at 400 deg. for 5 hrs. Etched dilute HCl × 270.

If a copper-beryllium alloy containing 2.5 per cent. of Be is heated up to about 800 deg. C. and is quenched in water or oil, it contains α solid solution, which is invariably found in a state of super-saturation and is of low hardness. The alloy is thus in an easily workable condition, and can, for instance, be rolled. At normal temperatures the hardness does not increase, because the inertia of the reaction of the alloy is too great in order for the supersaturated γ solid solution to be produced. It is only when the alloy is submitted to tempering between 200 and 400 deg. C. that the hard γ crystals show up in the α solid solution.

Metallographic researches have clearly demonstrated this. The authors have personally undertaken a systematic study designed to show the effect of ageing on a copper-beryllium alloy containing 2.2 per cent. of Be, as well as that of small amounts of impurities. This alloy, which is of the foundry type, when cast as sand-cast runners, yields the structure in the as-cast state shown in Fig. 10. From these runners, a series of samples were taken. They were all quenched at 800 deg. C. in water after a preliminary heating for about 2 hours. These samples were then tempered and aged at various temperatures for different periods. The effect of ageing was shown up by microscopic and Brinell-hardness tests.

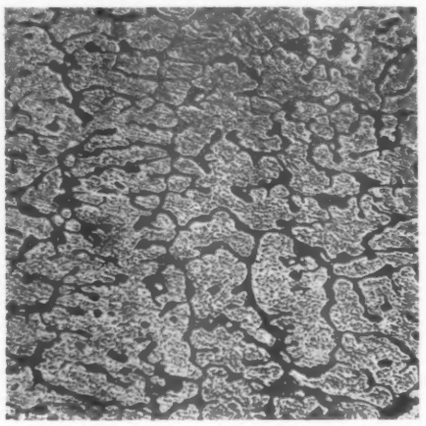


Fig. 7.—Cu-Be Alloy with 9.35 per cent. Be. Annealed at 400 deg. C. for 5 hrs. Etched with dilute HCl × 270.

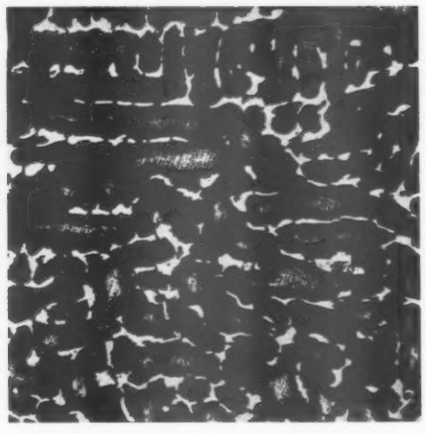


Fig. 10.—Sand Cast, As Cast. × 75.

As is revealed by Figs. 11 to 13, the initial structure of cast copper-beryllium alloy (Fig. 10) is notably affected by thermal treatment. By quenching α solid solution is obtained, and in it can be observed the presence of some residual specks of the γ (gamma) constituent remaining undissolved despite the preheating for 2 hours at 800 deg. C. (Fig. 11). The tempering and ageing re-establishes the field of two phases and sets up, by its longer or shorter duration and its more or less high temperature, a precipitation of

the constituents of greater or lesser magnitude (Figs. 12 and 13).

As to the variation of the Brinell hardness, this is shown up by the results set out in Table I and the curves of Fig. 14.

Examination of the results set out in Table I, in conjunction with the curves of Fig. 14, shows that the maximum effect of ageing is obtained by heating to 330 deg. C. for a period of 4 hours. At 375 deg. C. a similar hardness is obtained, after only half an hour's heating, but it rapidly

Fig. 11.—Quenched in Water after heating for 2 hrs. at 810 deg. C. × 270.

decreases if the period of heating is reduced below two hours. It is thus preferable to operate at the lowest temperature (330 deg. C.) and obtain the reprecipitation of the γ in a more progressive manner (4 hours).

The conclusions outlined above relate to foundry alloys containing 2.2 per cent. Be, and confirm the results of earlier work done on this subject.

Composition at Control of Industrial Cu-Be Alloys

As stated earlier, only low-content copper-beryllium alloys, that is to say, those containing

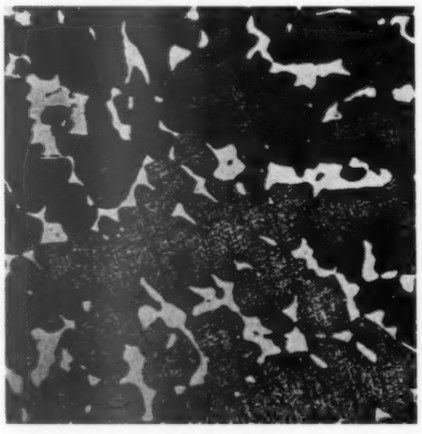


Fig. 12.—Quenched and Temper-aged at 250 deg. C. for 1 hr. Etched Ammoniacal Solution $CuSo_4$ × 75.

a maximum of about 3 per cent. of Be, are capable of industrial application. They happen to be those which are well capable of being aged.

Their compositional control is effected by a direct addition of stock alloy (containing 12 per cent. of Be and over) to a bath of melted copper. Before describing the *modus operandi* for this addition, it should be pointed out that high-content cupro-berylliums used as stock alloy can be made electrolytically by direct deposition.

Slomann[6] has stressed that one can advantageously use a cast cathode by using the electrolytic method of producing pure beryllium.

Thus, Be-rich cupro-berylliums which conform in every way as an addition with the object of obtaining the foundry type containing 2.25 or 2.50 per cent. of Be can be obtained.

Addition of Beryllium to Copper.—The operation is carried out in a graphite crucible in which

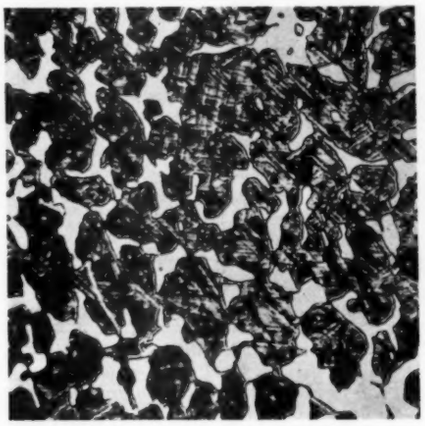


Fig. 13.—Quenched and Temper-aged at 330 deg. C. for 5 hrs. Etched Ammoniacal Solution of $CuSo_4$ × 135.

first of all copper is melted. This should be of high purity and for preference the electrolitic variety. It is protected from the action of air by a layer of charcoal or alkaline flux, and is meticulously deoxidised by special additions (calcium, silicon, lithium, boron or the like). On this subject, Cone has pointed out that copper boride can advantageously be used. This latter operation is very important, because if it is incomplete, serious beryllium losses will occur, as it has a strong affinity for oxygen, at the moment of adding the cupro-beryllium to the bath of liquid copper. Care must be taken to increase the temperature of the bath to neutralise the resulting chilling effect; then the bath is lighted

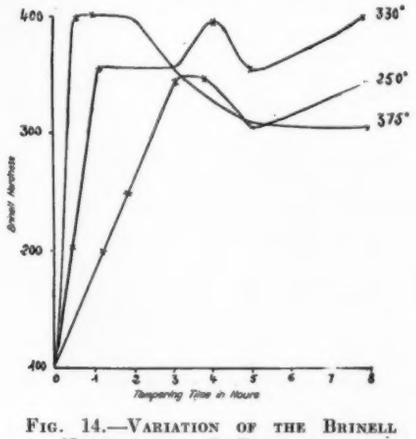


Fig. 14.—Variation of the Brinell Hardness of Cu-Be Alloy with 2.2 per cent. Be correlated with the Time of Ageing.

and stirred up, using either a graphite or nickel-chrome rod.

Casting.—The sand-casting of cupro-beryllium does not demand any special precautions. The metal is cast at a temperature of 1,050 deg. C. into moulds of which the confection is similar to those used for phosphor-bronze. The contraction of cupro-beryllium alloys of 2 or 2.5 per cent. of Be is, moreover, about the same as for the latter, probably of the order of 1.57 per cent. Cone has reported a total metallic loss of the order of 9 per cent. Personal experience has indicated that this figure can be materially lowered. In casting cupro-beryllium, cast-iron chills, preferably heated to 120 to 150 deg. C. and reeked, can also be used.

Thermal Treatment

Cupro-beryllium alloys above 3 per cent. Be should be submitted to a quench, followed by tempering and ageing in order to assume the highest mechanical characteristics. For this pur-

Table I.—*Variation of Brinell Hardness of a 22 per cent Be, Cu–Be alloy in relation to the temperature and duration of ageing (Laissus and Persoz).*

Tempering temperature in deg. C.	Brinell hardness, kg. per sq. mm. Duration of tempering in hrs.						
	½	1	2	3	4	5	8
250.. ..	140	196	253	337	337	313	337
330.. ..	208	365	365	365	396	365	396
375.. ..	396	396	396	365	337	328	313

Initial hardnesses: As-cast (sand cast) 107 kg. per sq. mm. Quenched at 800 deg. C. after reheating for 2 hours 108 kg. per sq. mm.

pose, the material is heated to 800 deg. C. for a period depending upon the mass of the castings, but averaging about two hours. It is obviously necessary to affect the solution of the constituents. This completed, the casting is water-quenched, and by this means a maximum softness permitting of easy machining is obtained. Maximum hardness is secured by temper ageing, preferably carried out in a salt bath controlled at 330 deg. C. for about three to four hours.

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5 H. Borchers. "Metalwirkschaft," XI, 317–321 and 329–330, 1932.
6 H. Slomann. "Met. Ind." (New York), Vol. 32, 7–16, February 25, 1934.

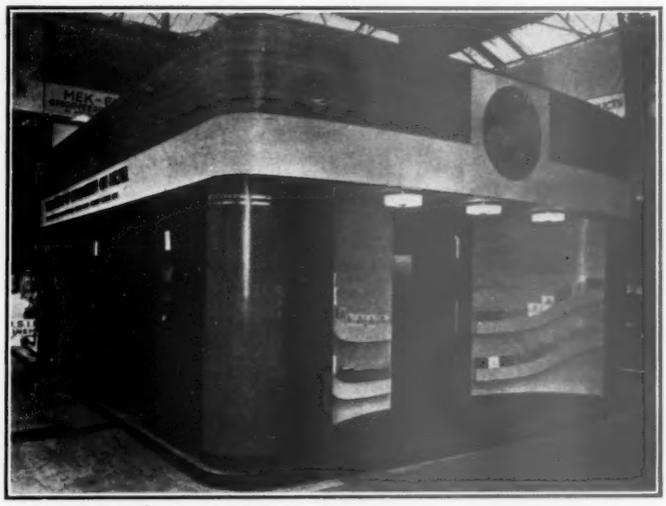
(To be concluded.)

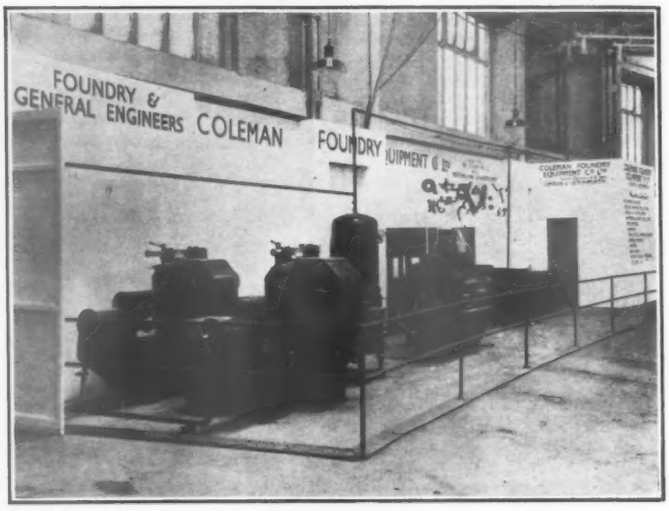
Catalogue Received

Welding and Riveting of Aluminium. It must not be presumed from its title that this 64-page brochure issued by the Northern Aluminium Company, of Banbury, Oxon, is of little interest to foundrymen. On the contrary, they cannot learn too much about it, and in its early stages, make it their servant instead of being a competitor. Being inherently light, there is not the same craze for weight saving as with ferrous metals, but on the other hand, there is a need for saving cost of metal, and it is this latter factor which demands the closest attention of the founder. There is, for many articles, the chance of making them as die castings, with which process neither welded nor riveted articles could compete. Reliable data for welding castings are given, accompanied by a number of useful hints for the operator. It should be appreciated that a mass of very valuable data has been assembled for riveting as well as for welding. As a piece of industrial publicity matter, this brochure indeed ranks high.

The seventh Birmingham ball organised on behalf of the Royal Metal Trades Pension and Benevolent Society will be held at the Grand Hotel on Thursday, October 28.

A Final Selection of Stands at the Foundry Exhibition at Olympia





Top Left.—Bureau of Information on Nickel.

Top Right.—Part of the Coleman Foundry Equipment Company, Limited's, Stand.

Centre Left.—Electromagnets, Limited.

Centre Right.—Thomas E. Gray & Company, Limited.

At Left.—The Ford Motor Company, Limited.

Applications of Autogenous Welding in the Foundry*

By R. GRANJON and H. GERBEAUX

At the International Foundry Congress in 1932 one of the authors† indicated the remarkable analogy existing between the operations of founding and welding. The phenomena accompanying or following fusion are present equally in the two processes, but with different intensity. The foundryman, because of his knowledge, is well qualified to take an interest in welding, yet it is astonishing that he often neglects this process to the point of ignoring the advantages he can derive from its use.

The authors have already dealt with the following possibilities of welding:—Recovery of defective castings with the object of reducing

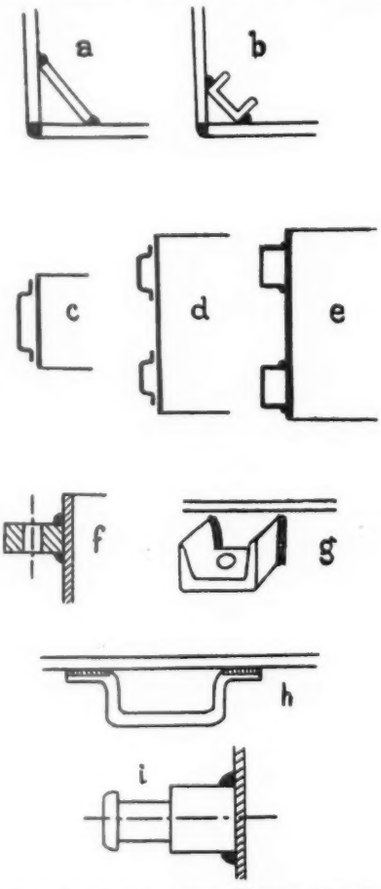


Fig. 1.—Lay-out for Welded Boxes.

a and *b*, reinforcements of the angle of the box, lay-out *b* is the better; *c* and *d*, light boxes strengthened by channel irons; *e*, heavy box strengthened by channel iron; *f* and *g* showing welded lugs; *h*, welded handles; *i*, welded trunnion.

wasters; repair of castings broken in manufacture; production of components made up of cast and rolled sections assembled by welding.

Finally, oxy-cutting has a utility of which foundrymen have not always availed themselves with equal competence.

At the same congress Renaud,‡ talking of the safeguarding and development of the use of cast structures, drew attention to the advances of welded construction in direct competition with castings. Dealing with the same subject, the authors have advised foundrymen to include the construction of welded assemblies in their manufacturing programmes, in order to preserve and even increase their *clientèle* rather than risk the competition of a new industry. Since then founding and welding have become stabilised in relation to one another, and their respective fields are better defined than was so a few years ago.

The authors are not going to return to the correction of foundry defects and repair of castings. Welding and weld-brazing technique are always being improved and their possibilities extended. A visit to the repair shops of any railway company is sufficient to convince one of this. It must be remembered, also, that the foundryman on his side devotes all his attention to producing irreproachable castings, and is becoming a little better at that every day, thanks to his technical progress.

It is only right to mention the great development made in oxy-cutting and its applications in steelworks, either for cutting scrap or for cutting fabricated products, either cold or red-hot, by means of special apparatus.

Of the numerous applications of welding in the foundry, the authors wish to discuss two, namely, the construction of foundry equipment and the constitution of composite components (cast and welded).

WELDED EQUIPMENT

Autogenous welding can be widely used for the construction and maintenance of foundry equipment. This modest *rôle* is far from being negligible by reason of the influence it can have on the economy and reliability of the fabricated parts. The essential qualities of foundry apparatus are solidity, rigidity, lightness and low cost price. By the use of thin rolled sections, and the economic addition of ribs and webs of the most efficient shape, autogenous welding permits of the building of units responding in every way to the qualities required.

Boxes

Whether the different phases of foundry work be manually or mechanically performed, there is always considerable handling of sand and boxes, which makes weight reduction desirable. The lightening of boxes is best secured by welding. Simple channel-iron construction is restricted to small boxes. Medium-sized and large boxes will be advantageously made up from a plate stiffened by U channels creating box sides of the utmost rigidity and permitting the most varied ways of handling without running the risk of mould distortion (Fig. 1).

With welded boxes breakages in the course of transport, storing and stripping are no longer to be feared. Lugs, handles and trunnions which are habitually the victims of rough handling, withstand the most severe tests if made of welded steel.

Smooth or ribbed box bars can be fastened to the body by welding. Removable bars prevent the usual inconvenience of being irremovable at the end of a certain period of service. This problem is economically overcome by oxy-cutting and welding ordinary bars, according to requirements.

Finally the lightening of the mould will more often be obtained if the foundryman arranges for it himself by cutting and welding special boxes for even small production series. Bottom plates, turnover boards and marking out plates ordinarily involve exaggerated weight for the rigidity obtained, and for large sizes one can make them up as panels in welded rolled sections (Fig. 2).

Grids

In reinforced concrete, it is now customary to substitute mesh by an assembly of rods. This yields a labour economy, more exact assembly and a greater overall strength. Undoubtedly, in the foundry, certain complicated core or mould grids could be similarly made. The low cohesion of the sandy material, through shearing action, makes it sink if the grids solely maintain the suspended parts. A welded grid would therefore reinforce the delicate parts of the mould, and its re-use would be possible in many cases, unlike composite aggregates of cast iron and steel used for large moulds.

Plates and Pattern Plates

The normal methods of moulding are in general very satisfactory. All the same, in certain cases the foundryman can advantageously have recourse to components, cut, machined and

Fig. 2.—Suggested Method of Making a Strong Metal Plate by Welding.

assembled by welding. This process—quite usual in vibrated concrete practice—furnishes particularly strong plates well suited for long runs.

Another method would consist of working up and welding thin sheets of practically stainless metal, such as Monel metal, aluminium bronze, or nickel silver, all of which are capable of taking a high polish. One can thus obtain a moulding surface which, when secured by the use of cement or a contractionless alloy, yields a perfect pattern. This method is now being used for making imitation stone or artificial-marble patterns, an excellent polish being initially obtained.

Ladles

It is possible to reduce by 30 to 40 per cent. the weight of a riveted ladle by the use of welding. Here again ribbed sections are found to be particularly robust, due to the fact that the essential material is put to the best use. By increasing the rigidity, the functioning of the tilting mechanism is improved—a much appreciated additional advantage (Fig. 3). A further step is the strengthening of the suspension hooks and rings of ladles by the use of chrome steels or stellitising. The belts of hand shanks can be lightened by the use of welded steel tubes, giving greater rigidity and allowing of the use of larger handles, which are better to handle.

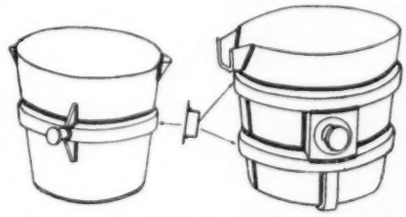


Fig. 3.—Suggested Construction of Welded Ladles.

Melting Plant, Furnaces and Stoves

Blast-furnace tuyeres, doors and their frames, valves of various types, hot-blast stoves, gas producers, ports and coolers for Siemens furnaces, bodies and reinforcements of furnaces (converters) and melting plant of all types, cupolas, muffles, boxes, annealing and case hardening pots can best be made by welding. Cheapness in construction, improved appearance and strength,

* Extracts from a Paper read at the International Foundry Congress in Paris.

† "Welding and Foundry Practice," by R. Granjon.

‡ "Problems referring to the Retention and Development of the Use of Castings," by F. Renaud.

and plain surfaces, easy of upkeep, are outstanding features. Alterations, repairs and changes to the sheet (plate) work are both easily and rapidly undertaken by welding.

Handling Apparatus

Conveyor plates, frame work of handling machinery and elevators, bogie bodies, save weight and achieve rigidity when made by welding. Rail joints, rolling stocks, monorail paths, bridges and gantries, when made up by welding, provide a continuity which eliminates shocks and jars liable to spoil moulds, and upset ladles, thus causing accidents. Lifting apparatus may overload the framework of the shop by their own weight, and welding permits a weight reduction of 15 to 25 per cent. by guranteeing an incomparable rigidity.

Sand Apparatus, Riddles and Bins

The thin, strong and perfectly smooth sides obtained by welding are well suited to plant used for stocking, handling, and preparing of sands, the structures made by this process being light and cheap. Many items, such as riddle frames, parts of mixers and aerators, knocking-out grids, tumbling barrels and sandblast apparatus, can rely on welding as a good servant.

Moulding Pits

Pits should be perfectly watertight so as to ensure proper dryness of the moulds, and these pits can be made at small cost by using thin welded sheets, reinforced where necessary, depending upon the dimensions, by a concrete lining.

Pipe Work

The modern foundry possesses a widespread network of pipes carrying high-pressure water and compressed air. It is obvious that leaks are extremely worrying. There is only one means of avoiding breakdowns and that is to use welded watertight connections carrying a minimum of detachable joints. Cutting and welding offer a means of repair quite as rapid as a detachable joint for later modifications. It would even be preferable for permanent apparatus to utilise welded tube work and not the usual screwed connections. It should be stressed that welded pipework for high pressure is now normally used for service pressures up to 7,200 lbs. per sq. in. and even more. Piping for blowing and ventilation, when constructed of thin sheet, gives the best outputs.

Buildings

Several conditions control the choice of type of construction, such as the resistance to corrosion by fumes, lighting, strength, cheapness and ease of upkeep. All are combined to the best advantage in a welded frame work. Watertight assemblies vastly superior to riveted work, looking smarter because of the absence of gussets, safe because of the high resistance to dynamic effects, economic due to metal saving, and with smooth surfaces allowing of easy upkeep, are outstanding possibilities. The use of welding can be extended to include the principal shops, stores, lean-to's, machine framework platforms, tanks and water towers.

CONSTRUCTION OF COMPOSITE COMPONENTS

This term is meant to cover castings intentionally including welded assemblies. They can be divided into several categories.

(1) *Homogeneous castings made in several pieces and assembled by welding.*

The parting of castings with the object of facilitating manufacture would be a fruitful technique either for steel or other metals, presenting difficulties in moulding in the following cases: (*a*) Where there are sections hindering contraction; (*b*) thin sections difficult to cast up with certain types of metal; (*c*) cast-on parts buried in the mould, fragile cores or those difficult to suspend, indicating almost certain defects in the casting; (*d*) varying thicknesses; (*e*) where quality control is impossible for certain parts; (*f*) high cost of complicated moulds; and (*g*) relatively weak castings and those of too great dimensions, where moulding costs are too high. These interesting potentialities are seldom envisaged by the founders. They would, however, allow of serious economies to be made and defects to be avoided. Prearranged welding would be of less importance than the repair-welding of a badly run casting. For cast iron there is now the quite normal case of weld-brazing of spun pipes. This weld-brazing in the shop of two or three lengths would have to be made in the field, whilst preserving portability, and the same system is used for making monobloc jobs. By this process leaks are completely eliminated, and cast-iron pipe now enjoys the same advantages of welded steel pipe.

(2) *Assemblies of rolled sections welded to steel castings.*

The manufacturer of welded framework is often forced to include certain complicated parts in his work by the incorporation of components made of steel castings. Recently, however, welded locomotive cylinders have been made for the French State Railway Company, and include numerous components made as steel castings.

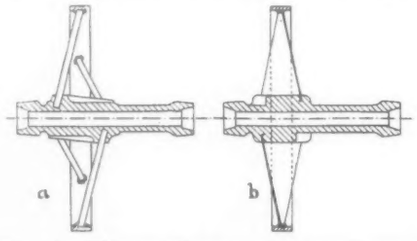


Fig. 4.—Welded Wheels for Agricultural Implements: (*a*) wheels carrying spokes, and (*b*) wheels made from steel sheet pressings.

Two opposing tendencies are to be noted:—(*a*) The welding specialist only desires to use rolled sections, and so loses time when making complicated structures, and thus turns out a poor looking job; (*b*) the foundryman only regards welding as the last expedient and prefers extraordinary complication instead of parting a job into two.

The author believes that many steel assemblies, such as locomotive cylinders, pressbed-plates, Diesel bed plates and reinforcements of the inter-sections of high-pressure receivers, would be improved if produced as composite entities, and this new technique should, in the nature of things, be carried out by the steel foundry.

(3) *Heterogeneous composite assemblies.*

By dividing components into sections suitable for welding, it would be possible to make an assembly with diverse materials, such as grey iron, mild steel, manganese steel, stainless, Monel, bronze, etc., each part playing its special *rôle* justifying its choice. Various welding processes allow such work to be carried out.

(4) *Heterogeneous iron-steel assemblies made by casting.*

This is a very old method of manufacture, and the only noteworthy modern development is an economy and a possible extension of the system by welding the steel part to be incorporated in the iron. Three types of construction are available:—

(A) The introduction into the mould of shaped pieces so as to obtain a cavity without having recourse to a delicate core. In this way such assemblies as those carrying holes for the circulation of oil, water or various fluids, bolt holes and the like, can be produced even when impracticable by any other method.

(B) Castings for which both iron and steel play distinctly different parts, such as wheels for agricultural implements where normally the rim and spokes are joined by riveting, but can be improved and made more rigid by a welded assembly. The standard form can be retained by using round or flat iron rods as spokes or by using the new system, that is, steel pressings, as shown in Fig. 4.

Many assemblies of this type can be envisaged with the object of: (1) improving cast-iron parts to be machined; (2) the saving of weight by substituting a thin wall of rolled material for a thick cast-iron one; (3) eliminating machining by incorporating in a casting a guide or a column of drawn steel, and (4) lightening the casting in cases where it is possible to state that certain portions are unduly stressed in tension or compression (triangular castings statically loaded).

(C) Iron castings reinforced or hooped by steel:—Finally, it should be pointed out that the modulus of elasticity of steel is about double that of normal grey iron; that the tensile strength of mild steel is relatively high and on this account it should be possible to incorporate irons in the tension-stressed parts of the iron casting so as to permit these heterogeneous pieces to act like reinforced concrete. This would result in a decreased weight coupled with a higher resistance to accidental overloading. Moreover, by encasing cylindrical castings such as columns, press parts, etc., in a sheath of welded sheet playing the part of a collar the strength of such assemblies can be materially increased. The author has no knowledge of like assemblies in any number, but believes the subject to be worth pursuing.

After having stated, for several years, how close the welding and founding techniques are, it has been the object of this Paper—perhaps too general in scope—to show some of the possibilities of collaboration of the two processes as affecting the actual foundry itself.

Book Review

Foundry Organisation and Management. By James J. Gillespie. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 12s. 6d. net.

Much has been said and written about industrial organisation and management in general, but very little upon the subjects as applied to the foundry in particular. Mr. Gillespie's book comes to fill this gap, and deals with the matter in a very capable manner. Much ground is covered, ranging from equipment, lay-out and labour selection to costing, accounting and finance, but the treatment is such that the essentials are made clear, although at times one would like to pursue the subject further.

The author very wisely differentiates between the needs of the large and small foundry, and makes no attempt rigidly to apply specific systems, whilst the many examples and alternatives described are very helpful.

Foundry costing is dealt with at some length, and the advantages to be gained by a reliable method are well emphasised. The fact that the system must be arranged to suit each particular case is recognised, and in consequence the particular chapters contain much that is worthy of consideration. The sections dealing with works planning are written with practical understanding and insight, and the performance of many foundries would be improved by the application of the principles indicated.

In Mr. Gillespie's book the experienced executive will find much that is helpful and stimulating, and the student will appreciate the lucid treatment of such a comprehensive and involved subject. In addition, the book has merit as a useful work of reference. A. W.

Choice of Plant in a Jobbing Foundry*

By ANDRÉ SISSON

Thirty years ago, 99 per cent. of the castings leaving the foundries were hand made. Machine moulding was still in its infancy. Apart from a few exceptions, which prove the rule, this process was only considered by foundries as a curiosity. The foundryman worked his machine to impress a customer during a visit. Times have so changed that nowadays it can be said that 80 per cent. of castings are machine made or, to be more precise, without the aid of a skilled moulder.

It is correct to state that the cult of hand moulding has not changed one iota throughout the centuries. The moulder's kit is still rudimentary. Unlike that of a fitter, which is highly developed, the former is unchanged—a shovel, a riddle, a bellows, and an assortment of various trowels, and the moulder is set up. If he is a clever craftsman, he will always earn a good living, as good moulders are becoming more and more scarce. His trade is not boring, because of its infinite variety, and the necessity for care, intelligence and initiative. A good moulder never need be out of work. An examination of the increasing desertion of this trade by youth, for the attractions of the newer motor-vehicle and aeronautical industries amongst others, is a matter to be deplored on their account, for they will never find amongst these crafts, subject as they are to alternate waves of depression and prosperity, the independence and security which is assured to the moulder's trade.

The consequence of this disaffection is that the engineering industries tend to free themselves from the foundry, and one now sees large engines built up without the use of a single casting. It is thus probable that the hand moulding foundry will meet more and more difficulties due either to lack of skilled operatives or to outside competition using a non-foundry technique.

On the other hand, machine moulding has, during the past thirty years, made considerable progress. In the Ardennes, for example, if one excludes one Charleville concern noted for its heating stoves, which since that time has used and kept secret compressed-air machines, there were not, in 1910, twenty machines in operation amongst the whole sixty foundries then existing in that area. To-day the district can certainly count up to 2,000 in actual use.

The perfecting of machine moulding to which the sand of the district readily lends itself; the excellent appearance of the products obtained by this system, such products entering without exception into every conceivable industry, have combined not only to compensate for the decline of hand moulding but in the direction of the expansion of the number of machine moulding foundries. The possibility of rapidly delivering, at a cheap price, large numbers of similar castings needing practically no finishing as they leave the mould, gives certain types of industry an extremely useful service. Amongst these are domestic heating, kitchen equipment, electricity and builders' castings. Under these circumstances, machine moulding rather than having caused unemployment, has created work for a large number of workmen, by creating for rich and poor alike large quantities of manufactured articles destined to improve the general standard of living.

In this sphere of machine moulding practically everything is new, as nothing, or practically nothing, existed thirty years ago. At that time, in France, Bonvillan and Ronceray and Morane had, with a good deal of trouble, succeeded in converting a few of the more enterprising concerns. Then came the Germans, especially Schmergel-Fabrik and Badische Maschinen Fabrik, and together they opened the eyes of the foundrymen. Under the impulse of Mr. Ronceray, the first foundry exhibition was opened in Paris in 1913, where four French moulding-machine manufacturers showed their inventions. Then came the war, and for four years moulding machines were worked to death. The coming of peace saw a great revival of foundry practice and machine moulding.

But the war, and its cruel necessities, had imposed on the foundry demands which made for progress of the greatest importance. Whilst the skilled craftsman worked incessantly, the scientist did not remain inactive. Physics, chemistry, and metallography were harnessed to the study of foundry practice, and resulted in the creation of new alloys. In this direction considerable progress has been achieved. Thirty years ago the foundryman had only a few mouldable alloys at his disposal; to-day they are to be numbered by dozens. Certain foundries exist solely for the manufacture of special alloys, which are prepared to buyers' specification, each alloy possessing its own peculiar properties, qualities and defects. The old-fashioned ball-drop arrangement, the only testing machine known thirty years ago, and to-day a common feature in the scrap yard, is now replaced by universal precision testing machines, evaluating the properties of diverse alloys, which have already been subjected to chemical and micro-scopical analyses.

All progress implies complexity. The old-fashioned foundryman, lucky fellow, was content with being a practical moulder. His modern counterpart has to be a chemist, physicist, moulder and mechanic. He must above everything else be a good business-man. He must be a man of vision, as conditions change so rapidly, and the necessity arises of constantly adapting himself to new conditions. For everybody, especially for those getting on in years, it is indeed a problem to select just what should be taught of their foundry practice in the schools—surely very little.

It has been shown that the art of foundry practice has sub-divided itself during the last thirty years into two branches, which are also distinct from each other. The first is the old hand-moulding foundry, tending to die out due to the lack of skilled moulders, the impossibility of real progress in moulding materials and the relatively high price of its products. The second is the new machine-moulding foundry, which possesses wide possibilities with good openings for young men and for the workman who, without entering into the category of skilled artisans, are no longer labourers, and who can often make more money than can be hoped for by the loose pattern moulder.

It is now proposed to examine the latter type of foundry, working with loose patterns, that is to say, a firm having a wide range of customers and to postulate what should be the main objects of its staff and executives animating the manufacturing organisation.

For instance, if the problem of staff is solved—a difficult matter for many foundries—the owner himself still has several commercial and technical worries, and three principal factors decide the future of the concern: labour recruitment, raw material accessibility (particularly sands) and the finding of customers. If a situation can be found where there are both skilled moulders and an adequate supply of suitable sand, so much the better.

Machine moulding, let it be said, is not anybody's job. To obtain output, it is essential that the workman possesses a number of qualities not universally inherent. In very specialised foundries, such as motor vehicle shops, where the same shift works on the same pattern for weeks on end, it is possible to be less exacting in the choice of workmen, but in a loose-pattern shop, where the moulder has to work with several patterns in the course of a single day, it is essential that he possesses well defined gifts, such as sportsmanship, physical strength, manual skill and a general knowledge adequate for moulding. These qualities can obviously be met with almost everywhere, but in districts where the foundry trades are not highly developed, trouble will be encountered in recruiting enough men to cope with any eventuality.

It is also deemed to be indispensable to have easy access to moulding sand of good quality. Fearless young men will ask: "What about synthetic sand?" Yet why worry about such sands when there are regions rich in natural

Fig. 1.—External View of a Jobbing Foundry.

In the foreground there is a rubbish bin surmounted by a water tower; the former is filled by skips, and lorries running beneath it eliminate hand labour. In the cupola building is seen a spark arrester surmounted by a single chimney.

* Translated from "La Fonte."

deposits possessing all the essential qualities and requiring but a minimum of working before use?

The transport of raw materials and manufactured goods to-day everywhere presents but little difficulty owing to the motor lorry, but becomes more or less onerous, according to the distance separating the foundry from centres of production and utilisation. As the railway still remains, however, the cheapest means of transport for heavy materials, it is obviously desirable, where possible, to be connected up by sidings or at least to be near to a station.

It is equally necessary for the jobbing foundry to be easily available to the *clientèle*, for it can only exist through constant contact with its customers. A visit from a customer quickly fixes up such matters as pattern modification and new patterns, where close collaboration of the foundryman and his customer is essential.

Fig. 2.—Interior View of the Foundry shown in Fig. 1.

In the left foreground is the knocking out and cleaning department, where the dust elimination is effected by suction pipes serving all dust-producing plant.

Fig. 3.—Handling by Monorail.

On the left a skip is shown leaving the sand-preparing plant and distributing its load to the sand bins shown in Fig. 2 at the side of the machines. On the right is a skip of old sand returning to the sand-preparing plant. In the centre is a third for handling knocked out castings to the fettling shop.

Once these elementary conditions have been fulfilled, the questions of buildings and raw materials arise. Most often, existing buildings are adapted and an endeavour is made to get the best out of them with a minimum of expenditure. It is essential that the lay-out of the buildings assures adequate hygienic conditions for the workmen and the rational movement of raw materials and finished products.

Next comes the question of lifting tackle. The machine-moulding foundry, having as a rule, only to handle small or medium castings, only requires an overhead travelling crane for exceptional jobs. The daily movement of sands, boxes and castings must be carried out in the cheapest and most rational manner by means of well-designed monorail, this system being easily the quickest and from an upkeep point of view the cheapest. It should be stressed that for machine-moulding foundries, where handling is always in the same direction and with the same objects, the use of the monorail is specially outstanding.

For melting, the cupola will for a long time remain the most generally employed unit, and even for many varieties of iron. However, in addition to cupolas, the jobbing foundry should provide themselves with either an oil or pulverised-fuel fired rotary furnace or an electric one if the price of current is favourable. These furnaces are particularly suited for giving metal of a definitely predetermined composition, calculated to meet the ever-increasing demands put forward by customers. This ability of the jobbing foundry to deliver special irons is to-day a vital factor.

So far as sands are concerned, the author favours the two-type system, facing and backing. In districts where good sands are available, the backing sand should need no treatment other than turning over with a shovel. Under such circumstances why should one be saddled with the continuous cost of an expensive upkeep bill due to passing sand through a plant which should, by the nature of things, have a capacity double or treble that necessary when using a two-sand system?

A general-purpose sand, moreover, is always ill-used, and to ensure its regeneration, a quantity of new sand, much in excess of that required when using two sands, is demanded. Its economy is only justified in stove grate foundries and not even then! The jobbing foundry, before it is in a position to make with equal facility the simplest or the most complicated casting, should be in a position to supply the moulders with a perfectly-treated sand having considerable

Fig. 4.—A Barrel Ladle Receiving Iron from the Cupola for Distribution by Monorail to all the Moulding Floors.

Fig. 5.—Castings Taken to the F[illegible] of the Moulding Floors are Placed on the Table shown at the left.

They pass to a rotary table sandblast machine and are distributed to the grinding wheels by rollers on inclined steel sheets. Between the wheels and the wall at the right are the inspection tables. Inspected castings are then sent by bogie wagons to the stores and despatch, the door of which is shown in the background.

"body," well aerated and in adequate quantities.

The semi-automatic sand plant shows the best promise of good results, if it has a minimum of complication, as sand weighs heavily against upkeep costs. The return of the old sand to the mill should be by monorail, as being the cheapest method available. The author has examined the potentialities, for a foundry mass-producing small castings, of the use of belts for the transport of moulds and the return of knock-out sand to the sand-preparing plant. He has equipped a complete section of his foundry with this system with the object of despatching to the machine shops all the mass-produced castings. At the end of six months of use, the costs were ascertained and the whole system dismantled.

Fig. 6.—Fairly Complicated Pattern Plates carrying High Overheads, each one of which has made tens of thousands of moulds.

At the right, there is shown a pile of iron filling-frames for moulds.

Moulding Machines for Jobbing Foundries

This question is a delicate one because of the large number of systems available. A fact which should always be kept uppermost in the foundryman's mind is that moulding machines operate amongst sand. The immediate result should be the choice of the simple types of machine admitting of easy and cheap upkeep.

At the risk of being labelled reactionary, the author believes—exceptional circumstances barred—that a stripping machine and the lever-operated moulding machine are the true tools for the jobbing founder. They are relatively cheap and can frequently be renewed. They demand a minimum of maintenance, accommodate themselves to all pattern-plate and plaster-pattern systems, and, moreover, can be handled by any type of workman.

Consider for a moment high-output machines, where it is necessary for them to give a production equivalent to two or three hand-operated machines. The servicing of the machine involves a large and continuous supply of sand, boxes, and rapid freeing of the moulds produced, casting and knocking out. This requires, in addition to a costly and delicate machine, a considerable amount of ancillary and expensive plant, and also a sufficient number of labourers at the disposal of the moulder to make the plant work. Moreover, in certain periods orders may be so scarce as not to allow economic production from such a machine, which alone can take care of the amortisation.

As plant for a jobbing foundry here and there success cannot be achieved by buying a more or less complicated and more or less well finished moulding machine, yet it is deemed that questions of pattern plates and boxes are of greater importance. The jobbing founder ought to provide himself with large quantities of series of boxes capable of meeting all requirements, and should be ready to create further series of boxes to meet the needs of fresh orders. It must not be forgotten that the box dimensions influence the cost of a mould, and boxes properly proportioned to the casting may sway the getting of an order.

Moulding Boxes

In this connection, practical experience has proved the three recommendations which follow to be valuable:—

(1) Boxes to be as light as possible; a thin, light cast-iron box will break much less easily than a heavy one. Besides, it is necessary to realise that large tonnages are carried during the day by the machine moulder. Twenty tons or more is not unusual.

(2) For small but constantly repeated orders, aluminium boxes are capable of giving a good account of themselves.

(3) The method which consists of always making the drags (4 in. maximum) and completing the necessary height by a steel sheet frame, either loose or fixed to the box by bolted feet, has much to commend it.

Casting twice a day naturally simplifies the problem of boxes. The author has done this for seven years and has always found it advantageous. The moulder needs half the space and half the boxes, and sometimes will use the same boxes three or four times a day.

Fig. 7.—Moulding Medium-Sized Castings on a Stripping Machine.

The box is formed by a bottom part surmounted by a filling frame of 15 cm. sheet steel. The box to be rammed up is on one of the cores shown at the left. The cores are stripped on a planed bottom plate. The mould is composed of this bottom plate and only one box part.

Fig. 8.—Moulding of a Round Pedestal.

In the centre is the unfettled casting, at the left a mould formed of two half boxes made in aluminium, is ready for casting. At the right a core about to be stripped on to a planed bottom plate. With only one box the moulder can make as green moulds during the day four castings each weighing 130 lbs. each.

Finally, it is by the thought and care bestowed upon his pattern plates that the jobbing founder shows his true worth. The choice of boxes being the best possible for any given casting, then a study of the joints, runners, cores, and the elimination of these wherever possible by suitable mechanical means, is carried out, as well as a survey of factors which control the production of a successful casting, and, of course, the cost price.

After stripping, the castings obtained should be carried to the fettling shop by monorail. This shop must be furnished with sand-blast apparatus carefully chosen to take into consideration the type of casting forming the normal output of the foundry. Brush cleaning ought to be suppressed everywhere as being unhealthy and dirty. It costs as much as sand-blasting and never gives such a good appearance. Amongst well-known sand-blast apparatus, the rotating table is the most generally used, the most practical and the one which gives the highest output.

The fettling shop should be furnished with some good heavy robust grinding wheels. These should be individually driven and carry carborundum-type wheels, especially when dealing with grey iron. A tumbling barrel, fettling tables for hand work or for using flexible-drive tools and grinders will complete the installation. The lay-out of the fettling shop is of primary importance. The machines should be so placed that the castings follow a logical route throughout the various operations to which they are subjected from their entry up to their despatch. They should never go back on themselves, a factor which will avoid blockages resulting in numbers of castings being held up. This inevitably starts trouble in the shop. The foreman should always have in front of him the idea that the heavier the castings the more they are likely to give trouble in fettling and the greater the liability of blockages. The author has noticed that in a large number of foundries fettling constitutes a more serious obstacle than moulding, in fulfilling of orders to the guaranteed time. This is especially true of malleable and steel foundries. The core shop in jobbing foundries is also of great importance, not only from the point of view of its equipment, which should be of the simplest character, but from the point of view of the accuracy of the cores, upon which factor largely depends the success of the ultimate castings. The plant should, above all, include a good sand mixer, a sieve, and a well-designed core stove. For some well-designed core shops rebated marking-off tables for stripping cores should be installed. Portable iron racks should be placed at the side of the core makers and then taken to the stove by small power-driven runabouts. One cannot stress too highly the importance of precision in the core shops as 80 per cent. of fins are due to differences in the dimensions of cores and their prints. These differences in dimensions are often the cause of scrap either through defective setting or because the flash stops up the vent and sets up blowholes.

To complete the foundry it is necessary to envisage a perfectly-equipped pattern shop carrying a staff capable of making any type of pattern in wood, plaster or metal. It should possess, in addition to wood and metal working machines, a special section for the preparation of plaster patterns and for tests on the stripping of plaster patterns and pattern plates, which should never reach the foundry before having undergone tests to prove complete satisfaction. It is also necessary to envisage a machine shop, not only for the repair of foundry plant, but also one which will allow of the execution of machined iron castings. The employment of a sheet-metal worker capable of doing some welding should be very useful, not only for the running repairs of the foundry, which can be carried out by the blowpipe or the electric arc, but for reclaiming defective castings. Moreover, it is to-day a *sine qua non* that even small foundries should establish a chemical and physical laboratory. The cost will be largely negatived by the possibility of undertaking really remunerative orders for special-quality irons which are showing an increased demand.

Delays in Delivery

The severe competition which has been experienced in the foundry trade during the past few years has reduced foundry profits to a minimum, unfortunately resulting only in an effort to reduce overheads to the lowest limits. If profits became normal the founder would be well advised to create a special service for the routing of orders at every stage of manufacture. This question is extremely complex. Numerous trials personally made by the author and others coming within their purview have underlined this. However, it would lend strength to the founder to be in a position to say to his client, "Your castings will be delivered on a certain day" instead of scarcely being able to tell him that they will be finished in some months' time. The industrial solution of such a problem is by the use of a Gant chart. In France there are several variations of these. They present no insuperable difficulty, and they place at the disposal of the management definite facts; they indicate the various difficulties related to either plant or shop morale. All have their solutions, but the solutions are always expensive. Another question which needs treatment is outside the technical sphere, and reference should be made to an extremely bad habit which exists amongst a number of French foundrymen and which does considerable harm to all jobbing foundry owners. This consists of neglecting to charge up to the customer the cost of patterns, pattern plates and special tackle specially made to carry out an order. Why do they not emulate other industries, such as those making pressings and stampings? This custom, which time and time again the author has brought to the notice of the employers' federations, is the cause of heavy losses to the foundry trade. It originates from laziness in not creating a proper costing department, with cognisance of overheads for the pattern shop. The founder who practises this system tends to attract customers who do not pay for cost of tackle. This is definitely a mistake for, for one customer so obtained, he loses a great deal of money. It is quite certain that there is no more faithful client than the one who pays against invoice the important cost of tackle.

The Foundry Owner

At the risk of repetition, it should be stated that the success of a foundry does not depend, as is often the case in other trades, on the simple buying of a more or less modern machine. It depends much more on the study of moulding, the design of pattern plates, and boxes. Yet it is essential for the foundry-owner or the manager to know the fundamentals of his job and himself handle the plaster or the sand. It is necessary that the staff which serves a hard and dangerous trade have full confidence in the directing head and in his skill.

(*Concluded from next column.*)

drying time is made; moreover, breakages are definitely of rare occurrence.

Finally, we would express our thanks to the management of J. & W. Baldwin, Limited, for giving us an opportunity of following through the manufacture of wood-wool rope carried out under essentially modern and excellently-organised manufacturing conditions.

HENRY WALLWORK & COMPANY, LIMITED, iron-founders and engineers, of Red Bank, Manchester, and George Angus & Company, Limited, engineers, of Newcastle-upon-Tyne, are to co-operate in their future activities, an association of interests having been arranged.

The Manufacture and Use of Wood-Wool Rope

Our representative recently had the privilege of inspecting the Birmingham works of J. & W. Baldwin, Limited, who established themselves in Salford Street, Aston, Birmingham, in 1895. Later, additional works was started at Manchester in 1926, under the title of J. & W. Baldwin (Manchester), Limited, in order to give increased and better service to the North of England.

The wood arrives as six to twelve foot lengths of logs, of which there seemed to be an incredible quantity in stock. First of all the ends are trimmed on a high-speed saw, and the logs cut to length. The cut logs are placed on to large-sized bogie wagons for transporting them to the wood-wool cutting machines. These machines, which take four logs at a time, are entirely automatic. A die first prints the grooves upon the wood surface, and knives then shear-off the pieces in relief. The choice of wood is important, and it must carry sufficient moisture or "bond" for the wood wool to be fashioned into rope. The rope-making machines, which are Baldwin's own design, for the most part are situated near to the wood-wool machines, as it is obviously bulky material to transport.

These rope machines are particularly interesting, as the diameter of the rope is controlled by the diameter of a case-hardened steel die, whilst the length made is measured automatically by a counter. The rope is wound on to spools, and the coils so made are standardised on a weight basis. The changing of a spool is but a matter of minutes. After stripping off, the coils are transferred to a light, airy, dry stores for despatch by covered lorries.

A second line of manufacture, carried out on a large scale at these works, is the baling of the wood wool for use by practically all industries for packing up fragile articles—cast-iron pipes and conduit-tubing being typical examples. The baling machine, whilst simple in operation, is a fairly complicated piece of mechanism, as the production of bales of wood wool, bound with wire to give a neat handy job, is continuous.

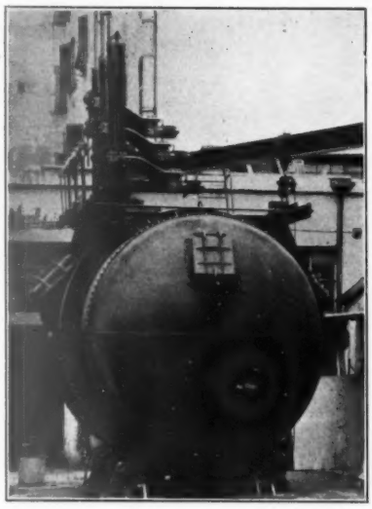
Use of Wood-Wool Rope

It is not our intention to enter into any controversy, as to the respective merits of wood-wool ropes, or those made from straw. The wood-wool ropes are unquestionably of much greater tensile strength, and even the smallest size made—that of $\frac{1}{4}$ in diameter—cannot be broken by the normal effort of an average man. The range available, by the way, covers sizes from this figure by $\frac{1}{4}$-in. increments to $1\frac{1}{2}$ ins.

Other advantages claimed for wood-wool rope, and set out below, are culled from correspondence placed at our disposal and emanating from the foundry managers of two of the largest foundries in Great Britain. The first, dealing with vertical-pipe manufacture, refers to the elimination of the danger of metal getting to the core bar, because wood-wool rope is rarely slack on the bar. Loam is never dislodged through curling during drying, such happenings being liable to cause hollow places between the corebar and the loam-coating, with the result that the latter will peel when in contact with the molten metal. His final remark is that, in general, a far stronger and sounder core is obtained, associated with full venting, when using wood-wool ropes.

The second manager, after referring to ameliorations due to increased strength, states that greater thicknesses of loam can be applied when wood-wool rope is used, and when more than one application is necessary, a saving in

(*Concluded in previous column.*)



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The Problem of the Elimination of Gaseous Impurities from Aluminium

Following the presentation of Prof. G. Chaudron's Paper* to the Derby Conference of the Institute of British Foundrymen, there has been some interesting discussion by correspondence, which is printed below.

MR. F. HUDSON wrote that all foundry metallurgists should be particularly indebted to Prof. Chaudron for his most interesting Paper. The problem of the gaseous impurities present in metal was a most important one, having a considerable bearing upon practical production problems, and it was a problem for which the average metallurgist had usually little facilities available for developing in the manner it deserved. In the foundry it was being increasingly recognised that gases played a large part in the successful production of castings, and whilst the practical worker would do as much as possible to counteract their effect, he must look to men like Prof. Chaudron to supply knowledge on the various fundamental factors entailed.

In this present Paper perhaps one of the most important facts brought to light was the doubtful value of tests conducted in vacuum, and one sincerely hoped that the discharge tube method might in the future be extended to the investigation of metals other than aluminium. If this could be done it would be of infinite value to the practical worker, particularly with respect to alloys containing nickel such as the straight nickel-copper alloys, which were extremely susceptible to the effects of gas absorption and furnace atmosphere.

MR. A. DUNLOP wrote that he had read Prof. Chaudron's Paper with very great interest, and was sure this contribution to the knowledge of gaseous impurities in aluminium would help towards the overcoming of this problem. He was particularly interested in the methods described for the determination of the gaseous content of aluminium. As pointed out in the Paper, the amount of damage done by the presence of gases in the metal was out of all proportion to the amount present, taken on a percentage basis.

With the "spark" method of degasification, used in conjunction with the bell jar test, much information regarding the efficiency of the practical methods used in the foundry for the removal and protection of the molten metal from gaseous impurities could be obtained. He would be very pleased if Prof. Chaudron would give a few more details of the bell jar test, and if he would say if he considered that this test could be applied to other alloys such as high nickel-content bronzes.

MR. J. S. G. PRIMROSE wrote that he considered the principal idea in the Paper showed clearly that there was usually much more gas content in cast aluminium than was generally shown by the ordinary method of analysis. The very interesting method of electron bombardment might seem fantastic to a foundryman, but the results quoted in the several tables given in the Paper brought to light a fact which could not be ignored in practical founding. That there was nearly ten times as much gas remaining in the solidified metal as was formerly estimated, made the present methods of partial degasification in the endeavour to eliminate pin holes appear almost futile, and the success in producing sound castings must therefore appear to be mainly due to careful melting practice, such as was recommended at the close of the Paper. Undoubtedly the care taken not to overheat the melt was very important, and the second claim that gases of combustion must not come in contact with the metal was much more difficult of accomplishment except in the case of the ideal electric furnace melting. Once the damage was done and the gases, which appeared to be chiefly carbon monoxide and hydrogen, were in solution in the molten metal, it would be a very useful application of the "spark" method of showing their presence, if it could be devised to extract them thoroughly from the metal before pouring it into the casting. Perhaps the author could state if the application of electron bombardment to molten metal in a crucible contained in a high vacuum would have the same desirable effect in extracting the dissolved gases as his results in Table I showed that it had on the solid metal.

Author's Reply

PROF. G. CHAUDRON wrote that he was extremely interested in the remarks following the presentation of his Paper. He wished to emphasise that the method of determining of gases called the "spark test" had already been utilised in his laboratory for metals other than aluminium, and especially by his collaborator, Mr. Moreau, who had used this process for the determination of hydrogen absorbed by iron in the course of cutting-off runners and risers by the oxygen blowpipe. Mr. Moreau's work had also covered the gas contained in magnesium, gold, copper, silver, palladium, platinum, etc. All these results would be printed in his thesis for his doctorate, to be published next month.

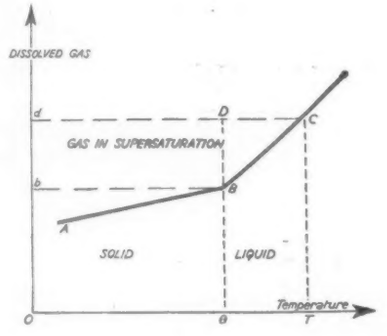

FIG. A.

In reply to Mr. Dunlop, who asked if the bell-jar method of testing could be generally applied, it was possible to state that this method had given good service in the laboratory for the practical testing of magnesium and its alloys, as well as for copper and certain of its alloys. Every time, however, there was a new adjustment to make, it was necessary to choose a suitable crucible which did not react with the metal and also to determine the temperature at which the vacuum had to be created. Mr. L. Moreau had carefully set out the conditions for the list so far as aluminium was concerned.

The "spark" method of gas extraction did not apply only to metals in the solid state. It could serve equally well for degassing metals in the form of very thin sheets or small diameter wires. This method was completely different from that which consisted of bombarding metal with electrons and of thus heating it to a very high temperature *in vacuo* (degassing by wireless valves). For the spark method the metal remained virtually at room temperature.

Finally, the author stressed again the cardinal conclusion of his researches, *i.e.*, that the "spark" method allowed the determination of the gas content in aluminium, but in comparing the results obtained with those given by the bell-jar method, it was shown that all gases did not play the same part in the foundry. Those which appeared to enter into the category of "supersaturated" left the metal at the moment of solidification and gave rise to blowholes. The others remained in solution in the solid state and had no appreciable influence on the properties. The classical diagram which showed the solubility of hydrogen in the solid and liquid states in aluminium was well known. Such a diagram showed a distinct discontinuity at the melting point of aluminium. It was not thought that this discontinuity was of great importance, but that the "rochage" (evolution of gas at solidification) was simply due to the evolution of dissolved gas at high temperature, that was to say, by supersaturation.

The diagram, Fig. A, was therefore put forward, and on it were shown sections of the curve AB and BC which met at the point B, the melting point of aluminium. The curve BC, which corresponded to the liquid state, showed that the solubility of the gas increased very rapidly with the temperature. Metal taken to the temperature T absorbed a volume of gas corresponding to the ordinate of the point C. By rapidly cooling and without stirring (or churning), one could arrive at the point shown at D. During solidification the gas in supersaturation corresponding to *d b* was evolved. That was the "rochage" of aluminium. The metal, however, retained a quantity of gas of which the value was given by the ordinate of point B.

It should be pointed out that for other metal, the "rochage" could be due to other causes, as, for example, in the case of copper. Here there was a reduction of the oxide by hydrogen dissolved in the metal and in the case of silver by a brusque change in the solubility of silver oxide.

* FOUNDRY TRADE JOURNAL, Vol. 56, pp. 509-510.

Fusible Alloys Containing Tin

Many interesting and surprising applications of fusible alloys are described by E. J. Daniels, M.Sc., in Technical Publication Series B, No. 5, of the International Tin Research and Development Council. In this monograph of twenty-two pages, ten pages are devoted to considering the bearing of composition upon the melting point and the structure and physical properties of the fusible alloys. Another ten pages describe their applications, and the references to published literature on the subject occupy the other two pages. It is shown that Wood's metal, Lipowitz's alloy and other well-known compositions are extremely close approximations to the eutectic mixtures of phases consisting of either pure metals, solid solutions of one metal in another or intermetallic compounds. The microstructure is important since the strength and behaviour of the alloys depends on it. It is important to cast the alloys under controlled conditions to get dependable results, in regard to plasticity and creep. The solidification of many of these alloys is accompanied by expansion instead of contraction because they contain bismuth or antimony. The problems of corrosion of fusible alloys and methods of avoiding troubles due to this cause are discussed.

Amongst the applications given are sprinkler plugs, boiler plugs, fusible links, seals for glass apparatus, patterns for moulding and electroplating, tube bending, tempering baths and die-mounting. Copies of the publication may be obtained free of charge from the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C.2.

THE BRITISH ALUMINIUM COMPANY, LIMITED, is inviting shareholders to subscribe for £1,000,000 new ordinary shares at 42s. 6d. a share. The new issue is to provide funds to complete the present programme of expansion at Lochaber.

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This Week's News in Brief

Trade Talk

G. & J. Weir, Limited, Holm Foundry, Cathcart, Glasgow, are erecting social and welfare buildings for their employees.

The Yorkshire Copper Company, Limited, of Leeds, are to build new works on the main Paisley Road, Barrhead, Scotland.

Wm. Denny & Bros., Limited, Dumbarton, have received an order for a twin-screw motor ferryboat, 130 ft. long, from the Elder Dempster Lines, Limited.

General Refractories, Limited, has acquired the whole of the share capital of the old-established business of Charles Davison & Company, Limited, Buckley, Flintshire.

Members of the National Union of Foundry Workers employed at Blackness Foundry, Dundee, stopped work last week-end as a protest against one employee refusing to join the union.

Barr & Company (Brassfounders), Limited, Cartsburn Foundry, Orchard Street, Greenock, has been formed with a capital of £6,000. It is a private company, and the directors are Mr. Thomas C. Riddell, Mr. Ian M'Callum Lang, and Mr. James Vandalle Fulton.

The Hammond Lane Foundry Company, Limited, Dublin, has just acquired the business of the brass and bell foundry carried on by the late Mr. Matthew Byrne. This foundry is being extended, and new plant is in course of installation for the production of a wide range of brass castings and pressings.

Die Casters, Limited, a Melbourne organisation, have opened negotiations with the object of establishing the manufacture in this country of motor fittings by the patent processes and methods of the Australian company. In all probability experts will be sent from the Commonwealth to establish production.

A joint meeting is to be held between the Midland Metallurgical Societies and members of the Iron and Steel Institute resident in the Birmingham district. The meeting will take place at the James Watt Institute, Great Charles Street, Birmingham, on October 14, 1937, at 7 p.m. Mr. T. G. Bamford, President of the Staffordshire Iron and Steel Institute, will take the chair, and the following Paper will be presented and discussed: "Notes on Some Recent Experiments in Connection with the Spraying of Steel by the Wire-Fed Metal-Spraying Pistol," by R. R. Sillifant.

Among those who have already accepted invitations for the annual dinner of the Institution of Mechanical Engineers, which is to be held at the Connaught Rooms, Great Queen Street, London, W.C.2, on October 15, are:—The Rt. Hon. Sir Thomas Inskip, C.B.E., K.C., M.P. (Minister for Co-ordination of Defence), Sir Herbert J. Creedy, G.C.B., K.C.V.O., (Permanet Under-Secretary of State for War), Lieut.-General Sir Reginald S. May, K.C.B., K.B.E., C.M.G., D.S.O. (Quarter-Master-General to the Forces), Engineer Vice-Admiral Sir Harold A. Brown, K.C.B. (Director-General of Munitions Production to the Army Council), and Air Marshal Sir Wilfrid R. Freeman, K.C.B., D.S.O., M.C. (Air Member for Research and Development).

The Joint Committee on Materials and Their Testing has arranged its first technical discussion to take place in the College of Technology, Sackville Street, Manchester, on October 29, commencing at 2.30 p.m. Three important Papers on different aspects of notched bar impact testing will be presented, as follow:—"The Physical Meaning of Impact Tests," by Prof. R. V. Southwell, M.A., F.R.S., M.I.Mech.E., F.R.Ae.S.; "Some Aspects of the Notched Bar Test" (in two sections, namely, a brief review of past experiments in this country and an experimental exemplification of several features of the test), by Mr. L. W. Schuster, M.A., M.I.Mech.E., M.I.E.E.; and "The Development and Present Position of Continental Research on the Notched Bar Impact Test," by Dr. Ing. Max Moser, of Essen. The chair will be taken by Mr. F. O. L. Chorlton, the President of the Manchester Association of Engineers. Further details may be obtained from the secretary, the Manchester Association of Engineers, St. John Street Chambers, Deansgate, Manchester, 3.

Personal

Mr. V. M. Drury has been elected chairman of the Canadian Car & Foundry Company, in place of the late Mr. W. W. Butler.

Mr. A. J. Grant, managing director of Thos. Firth & John Brown, Limited, has been elected a director of the Park Gate Iron & Steel Company, Limited.

Mr. Joseph Walton has been appointed a director of Thos. W. Ward, Limited. For 33 years he has been connected with the rails and railway sidings department.

Miss E. C. Elliot, secretary of The Institute of Vitreous Enamellers, has changed her private address from 6, Ranelagh Avenue to 42, Napier Court, Hurlingham, London, S.W.6.

Dr. Fritz Springorum has resigned from the chairmanship and general-directorship of the Hoesch-KölnNeuessen A.-G. für Bergbau und Hüttenbetrieb, Dortmund. Dr. Springorum, who is 53 years of age, suffered a breakdown in health about a year ago from which he has not yet recovered. He was responsible for the merger in 1930 of the Hoesch steelworks, with which his family has been associated for many years, and the Hoesch-Neuessener Bergwerksverein, of Essen. From 1930 to 1932 he shared the direction of the concerns with Dr. Winkhaus, continuing as sole managing director after Dr. Winkhaus's death in 1932. Dr. Springorum is succeeded by Herr Erich Tgahrt, Neunkirchen (Saar).

Commencing with the issue of January 6, 1938, the annual subscription of "The Foundry Trade Journal" will be 17s. 6d. home, 20s. foreign. Single copies 6d. each.

Wills

Ripper, William, of Brighton, Emeritus Professor of Engineering in Sheffield University £15,028

Rose, C. W., of Sheffield, a departmental manager of Hadfields, Limited, steel manufacturers £4,716

Obituary

Mr. Thomas Hall, who has died at his home in Sheffield, was for 39 years foundry manager for the Brightside Foundry & Engineering Company, Limited.

Mr. George William Mullins died at his home at Edgbaston, last week, in his 71st year. Mr. Mullins entered the brass and copper trades in 1885 as a clerk in the offices of the Adderley Park mills of the then Birmingham Small Arms & Metal Company. In 1891 he joined the staff of the newly-formed King's Norton Metal Company, with which he remained until 1919. In 1912 he was appointed to represent the King's Norton Metal Company on the Cold-Rolled Brass and Copper Association, of which, in 1918, he became chairman. During that period he was invited to give his whole time to the work of the Association as director, and he entered upon that office in 1920. Mr. Mullins was a member of the Council of the British Non-Ferrous Metals Research Association, and he was also closely connected with the work of the British Standards Institution. He had been an active member of the management board of the Copper Development Association, and other industrial activities included membership of the Grand Council of the Federation of British Industries. It was as a member of this body and as chairman of the Fiscal Policy Joint Committee of the Metal Trades that he was present at Ottawa in 1932 as one of the F.B.I. representatives available for consultation as required. In commemoration of the fiftieth anniversary of his entry into the non-ferrous metal industry in 1935, he was presented with an illuminated address at a gathering at the Birmingham Chamber of Commerce.

Company Meetings

Hale & Hale (Tipton), Limited

Presiding at the first annual meeting of the shareholders of Hale & Hale (Tipton), Limited, held in Birmingham recently, Mr. W. Edgar Hale, J.P. (chairman and managing director) said that the year had not been one of simple procedure for the management; they had had to contend with a series of difficulties, substantially unforeseen, which had affected every firm concerned in the iron and steel trade. Particularly, he referred to the shortage of hematite, which had been brought about by a general world shortage and had been further aggravated by the warlike disturbances in Northern Spain. He regretted that, for these reasons, they had been unable to deliver to their existing customers a greater tonnage of malleable iron castings than they had done, and also that they had been unable to execute business for many prospective customers who were desirous of placing business with them. Subject to no exceptional circumstances arising he felt that they could look forward to a successful year.

Qualcast, Limited

At the annual meeting of Qualcast, Limited, held at Derby last week, Mr. J. E. V. Jobson (chairman and managing director) said that the year's operations had resulted in a record profit of £74,900, which had been achieved by the extension of the company's activities, their turnover being up over 30 per cent. on last year. Commercially speaking, there was no reason why they should not continue to make progress. Trade in the country was good, and the situation was not entirely due to the production of armaments; these, of course, helped, but at the bottom trade was in a sound state, and their own results, as an example, had not been attained through large armament contracts, but on the legitimate bread-and-butter day-to-day work.

Company Reports

British Piston Ring Company, Limited.—Profit for twelve months ended July 31, after depreciation, expenses, and taxation, £59,659; brought in, £30,034; dividend on 7½ per cent. cumulative "A" preference stock, £1,500; dividend on 5 per cent. cumulative redeemable "B" preference stock, £2,500; interim dividend on the ordinary stock at 7½ per cent., £11,250; final dividend of 17½ per cent., £26,250; to general reserve, £15,000; carried forward, £33,193.

F. H. Lloyd & Company, Limited.—Profit for year to June 30, after providing for income-tax, pension fund insurance, depreciation, repairs and maintenance of buildings, plant, etc., and fees, £30,181; brought in, £23,501; 5 per cent. cumulative preference dividend, £1,889; ordinary dividend of 5 per cent., making 8 per cent. for the year; employees' superannuation fund, £1,850; to taxation reserve, £3,000; to general reserve, £10,000; carried forward, £22,992. The share premium, less expenses, resulting from the issue amounted to £18,343, and the directors recommend that this amount be consolidated into the general reserve.

Forthcoming Events

OCTOBER 8.

Manchester Association of Engineers:—Opening Meeting. Presidential Address, Presentation of Awards, Smoking Concert, at the Engineers' Club, Albert Square, Manchester, at 7.15 p.m.

OCTOBER 13 TO 15.

Institution of Mechanical Engineers:—Discussion on Lubrication and Lubricants at the Central Hall, London, S.W.1.

Institute of British Foundrymen

OCTOBER 9.

West Riding of Yorkshire Branch:—Paper "The Effect of Copper Additions to Cast Iron and Cast Steel," by W. B. Sallitt, at the Technical College, Bradford, at 6.30 p.m.

OCTOBER 13.

London Branch:—Presidential Address by Dr. A. B. Everest, Ph.D., and address on the work of the Institute's Technical Committee by J. W. Gardom, at the Charing Cross Hotel.

The Institute of Vitreous Enamellers

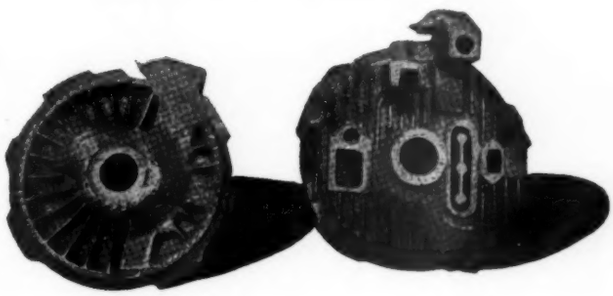
OCTOBER 8 TO 10.

Annual Conference at Birmingham.

There are various grades of YORKSHIRE SAND

Yorkshire Sand is of a synthetic nature, its production being under careful laboratory control. Perfect standardization is obtained with the various grades, suitable for light and the heaviest steel castings.

It is because of the refractability of the sand and of the toughness of the mould surface that castings made with Yorkshire Sand are distinguishable by their excellent finish.



YORKSHIRE SAND

for "easy stripping"

Information regarding the most suitable grades of Yorkshire Sand for your particular needs and full technical details will be given without obligation.

SOLE PRODUCERS

GENERAL REFRACTORIES LTD.,

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Genefax House, Sheffield

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LONDON OFFICE: Russell House, Adelphi, W.C.2. Telephone: Temple Bar 361 Telegrams: "Genefax, Rand-London" (Mr. A. C. Turner)

SCOTTISH OFFICE: 48, West Regent Street, Glasgow. Telephone: Douglas 6108 Telegrams: (3 lines) "Genefax, Glasgow" (Mr. C. A. G. Thomson)

SWANSEA OFFICE: Metropole Chambers, Wind St., Swansea. Telephone: 3680 Telegrams: "Genefax, Swansea" (Mr. D. F. Hood-Williams)

MANCHESTER OFFICE: 9, Albert Square, Manchester, 2. Telephone: Blackfriars 6130 Telegrams: "Genefax, Manchester" (Mr. S. G. Throssell)

MIDDLESBROUGH OFFICE: Halifax Bldgs, Exchange Place. Telephone: Middlesbrough 3313 Telegrams: "Genefax, Middlesbrough"

CARDIFF OFFICE: 17, Windsor Place. Telephone: 5796 Telegrams: "Genefax, Cardiff" (Mr. F. E. Rutter)

Other Moulding Sands include—Zenith Red Sand, York Yellow 102 Sand, Scottish Rock Sand, Bramcote Red Sand, Harperley Sand, Hensall Sand, Red Rover Sand, Warsop Sand, Mansfield Sand.

Raw Material Markets

The demand for iron and steel abroad appears to have declined somewhat, and, as a result, imports into this country have been heavier. Thus, the position is easier and consumers are receiving rather better deliveries. The question of prices continues to prohibit the transaction of business for next year and both producers and consumers would welcome some intimation as to the quotations which will rule after the turn of the year.

Pig-Iron

MIDDLESBROUGH.—Costs of production are high and are still rising, and there can be little doubt that consumers will have to pay more for supplies of pig-iron in the New Year. At the present time, users are still very short of their full contract tonnages and there is not much hope of any immediate improvement in the position; indeed, the distant view is not very favourable. Until the new price list is made known, deliveries after December 31 are charged at the rates ruling at the time of despatch. Apparently the easier conditions which recently have prevailed with regard to hematite have been short lived, as consumers are now calling for heavy tonnages, especially of the special grades of iron. As a result, it is likely that exports will again have to be given only secondary consideration.

LANCASHIRE. — Despite the decreased activity among some of the light-castings establishments, consumers are still taking up all available supplies and there is no surplus anywhere. Makers have substantial delivery arrears still to overcome, so that the prospect of placing new business is very slight. Hematite is in rather better supply, East Coast material particularly so. Prices are unchanged, with the exception of Scottish foundry iron, which is now quoted around 140s. per ton for delivery in the Manchester area, but supplies are very short.

MIDLANDS. — The improvement in the supply position in this area has been fully maintained and the only doubt concerns hematite, the demand for which is insistent. Most furnaces do not possess stocks, as there is little or no surplus left after contract commitments have been met. The controlled prices for ordinary No. 3 iron are 103s. 6d. for Northants No. 3 and 106s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, delivered to Birmingham and Black Country stations. Low-phosphorus iron varies considerably, according to the district from which it emanates, and is quoted at from £6 10s. to £7 5s. Refined pig-iron is controlled at £8 2s. 6d. minimum. While supplies of East Coast hematite are freer, there is still considerable difficulty in obtaining adequate tonnages.

SCOTLAND.—Most consumers are able to obtain satisfactory supplies of pig-iron, but no stocks can be accumulated and new business is not welcomed by producers. The official minimum prices of foundry iron are now 118s. for No. 3 foundry f.o.t. furnaces and 120s. 6d. for No. 1. No. 3 Cleveland iron is unchanged at 104s. f.o.t. Falkirk and 107s. f.o.t. Glasgow. Pig-iron supplies at the steelworks are adequate to ensure a good rate of activity and it is reported that stocks are being made up at some works. Hematite mixed numbers are quoted at 123s., with Scottish basic at 107s. 6d. and English and Indian basic at 100s., all less 5s. rebate.

Coke

All grades of coke are well inquired for and the market is very firm. For delivery to Birmingham and district, best Durham coke is quoted at a minimum of 52s. 6d. per ton, with Welsh coke at from 52s. 6d. to 69s., according to quality. The price of Durham foundry coke is controlled and is not expected to be changed before the New Year.

Steel

There is no relaxation in the pressure from consumers to secure delivery against contracts, and the whole of the production of the steelworks is passing at once into consumption. These conditions are likely to rule for some months to come, and the majority of the steelworks will almost certainly enter next year with a heavy tonnage of unexecuted orders on their books. In these circumstances the volume of new business is naturally restricted, since neither the makers nor consumers are anxious to add to the present congestion. Stringent conditions continue to rule in the semi-finished steel section of the market, and, although the production of the British works is pressed to the utmost, it is still not large enough to supply the quantities needed by users. Imports from the Continent against the quota, however, appear to be increasing and should help to ease the situation. The demand for finished steel is unabated, but it is almost impossible to find a works in a position to accept business for delivery before the end of this year. New business is quiet with oversea markets, but considerable deliveries are being made against old contracts.

Scrap

In connection with the campaign to release supplies of scrap, the British Iron and Steel Federation has circularised 150 towns in an endeavour to discover what happens to discarded household scrap. Every year local municipalities collect 400,000 tons of ferrous metal, and as far as is known, only 50,000 tons of metal is being recovered yearly. It has been stated that in three places, all of similar population, one saves 400 tons of scrap metal, one 1,000 tons, and the third not a single ton. Most consumers of scrap are fairly well supplied, but the present position does not facilitate the accumulation of stock.

Metals

Price fluctuations have been considerable. The outlook remains very uncertain and it would seem that further price reductions are likely before there is any material recovery. Following substantial falls in prices on Tuesday, further and heavier declines took place yesterday (Wednesday).

Copper.—It is officially announced that the companies operating within the copper restriction scheme have agreed on a programme of production which will result in a reduction of output to 105 per cent. of the basic quotas by the end of November. Seven companies, which control about 75 per cent. of the total world output, excluding the United States, are affected. Production will now be curtailed by between 20 and 25 per cent. from its current rate. The standard tonnages of the seven companies were fixed on actual production prior to the formation of the restriction agreement in the spring of 1935. They total approximately 600,000 tons, which is about 60 per cent. of the companies' full productive capacity. With the quota at 105 per cent., production from the restricting mines should be approximately 630,000 tons per annum, which means that output will be cut by about 200,000 tons per annum. The restriction agreement does not include the International Nickel Company, one of the largest copper producers in the world, but this company co-operates with the restricting concerns. Rather weak conditions have prevailed in the copper market during the past week and prices have fallen still further. It is suggested that the Hitler-Mussolini peace talks were responsible for part of the easier tendency. In the United States, the Customs smelters have raised the price of domestic copper to 12¾ cents. Many producers are quoting 13 cents per lb. for domestic copper. The Phelps Dodge Corporation announces that it is putting into effect a curtailment programme which is expected to reduce output by 20 per cent., and it is believed that most of the other high-cost producers, such as Anaconda, will follow their lead with the object of preventing the accumulation of supplies.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £47 5s. to £47 6s. 3d.; Friday, £48 18s. 9d. to £49; Monday, £50 2s. 6d. to £50 5s.; Tuesday, £48 12s. 6d. to £48 13s. 9d.; Wednesday, £45 12s. 6d. to £45 15s.

Three Months.—Thursday, £47 5s. to £47 6s. 3d.; Friday, £48 17s. 6d. to £49; Monday, £50 2s. 6d. to £50 3s. 9d.; Tuesday, £48 10s. to £48 12s. 6d.; Wednesday, £45 15s. to £45 17s. 6d.

Tin.—It is difficult to attribute the easiness of this market solely to the peace talks of Herr Hitler and Signor Mussolini. There has been little buying on American account, while the Soviet Union has also been quiet, but Japan has continued to place inquiries, chiefly in the East. United States tinplate mills are now operating at around 100 per cent. of normal capacity, against 107½ per cent. a short time ago. The weekly market report issued by Rudolf Wolff & Company states that "in the irregular circumstances which have prevailed, business with consumers has for the most part been on a reduced scale. The decline is difficult to explain, for the situation has not apparently undergone so essential a change as to warrant the sudden decline; on the contrary, consumption is reported to be well maintained, but sentiment has received a marked setback and the general depression prevailing has affected this market. With regard to supplies, it seems not unlikely that production will gradually increase, and it may be that the tendency in the future will be for stocks gradually to accumulate; but this possibility has not been lost sight of in the last weeks and would scarcely account for the weakness, for with returning confidence there might follow some improvement in consumption which would in a measure counteract the increase in supply. Moreover, if output increases at all, it can only be a slow process over ensuing months." The following tin statistics have been compiled by Mr. W. H. Gartsen (Henry Rogers, Sons & Company):—Total visible supply, 18,419 tons (September 30), against 20,167 tons (August 31); carry-over in Straits Settlements, 2,395 tons, against 3,332 tons; carry-over at the Arnhem (Holland) smelter, 1,227 tons, against 1,665 tons.

Official quotations were as follow :—

Cash.—Thursday, £244 10s. to £245; Friday, £242 15s. to £243 5s.; Monday, £250 to £250 5s.; Tuesday, £242 10s. to £243; Wednesday, £233 5s. to £233 15s.

Three Months.—Thursday, £243 to £243 5s.; Friday, £241 10s. to £242; Monday, £248 12s. 6d. to £248 17s. 6d.; Tuesday, £241 5s. to £241 10s.; Wednesday, £232 to £232 10s.

Spelter.—Consumers have shown comparatively little interest in the market, which has been quiet. In the United States, also, consumers have kept out of the market, for the reason that they are well stocked. The price has been reduced to 6.50 cents per lb. East St. Louis.

Daily market prices :—

Ordinary.—Thursday, £19; Friday, £19 5s.; Monday, £19 16s. 3d.; Tuesday, £19; Wednesday, £17 12s. 6d.

Lead.—In sympathy with the general trend of the markets, lead has been dull. The current number of the "Building Industries Survey" states that activity in the building industry continues at a very high level, but seasonal factors now begin to exert their influence. There is normally a progressive fall in building activity until a low point is reached in January, the actual movement depending largely on the weather. The survey points out that a decline in housing is no ground for the prediction of a building slump.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £19 3s. 9d.; Friday, £19 3s. 9d.; Monday, £19 11s. 3d.; Tuesday, £19 3s. 9d.; Wednesday, £17 16s. 3d.

Scrap.—Consumers are naturally reluctant to enter into forward business while the outlook is so uncertain, and, consequently, the inquiry has not been very substantial. Prices continue to decline.

Approximate selling prices for old metal:—New aluminium cuttings, £82; rolled, £67; cast, £42; foil, £94 to £98. Copper, £45 to £48; braziery, £44. Brass (clean), £27 to £30. Zinc, £13 10s. Lead, £17 15s. Gunmetal, £47 to £49.

Contracts Open

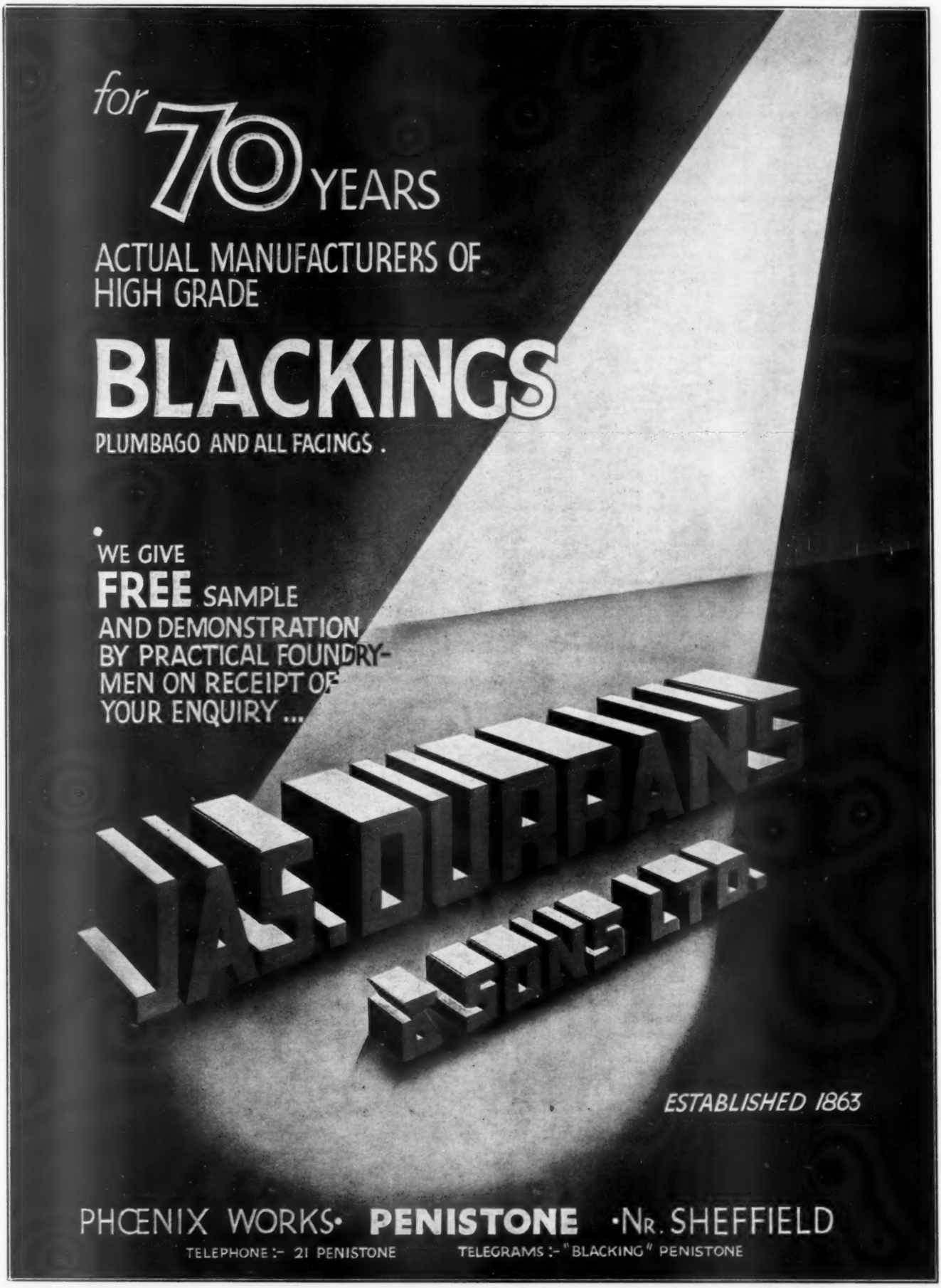
Caistor, October 20.—Provision and laying of 9,600 yds. of 2-in. and 3-in. dia. spun-iron pipes, cast-iron specials, fittings, etc., for the Rural District Council. Mr. J. H. Haiste, consulting engineer, Middleton Chambers, Lowgate, Hull. (Fee £2 2s., returnable.)

Montevideo, November 22.—100,000 kilogs. of pig-iron for foundry use, for the Uruguayan State Electricity Supply and Telephones Administration. The Department of Overseas Trade. (Reference T.Y. 19,705/37.)

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Listard Processing, Limited, Dursley, Glos.—Capital, £5,000. To operate the Listard chrome hardening process, etc. Directors: R. B. Lister, F. H. Lister, and H. Vasseur.


for 70 YEARS
ACTUAL MANUFACTURERS OF HIGH GRADE
BLACKINGS
PLUMBAGO AND ALL FACINGS.
WE GIVE
FREE SAMPLE
AND DEMONSTRATION
BY PRACTICAL FOUNDRY-
MEN ON RECEIPT OF
YOUR ENQUIRY...
JAS. DURRANS & SONS LTD.
ESTABLISHED 1863
PHŒNIX WORKS· PENISTONE ·NR. SHEFFIELD
TELEPHONE :- 21 PENISTONE
TELEGRAMS :- "BLACKING" PENISTONE

RAW MATERIALS—PRICE LIST

(Wednesday, October 6, 1937)

COPPER

	£	s.	d.
Standard cash	45	12	6
Three months	45	15	0
Electrolytic	52	0	0
Tough	51	5	0
Best selected	51	15	0
Sheets	84	0	0
India	63	2	6
Wire bars	53	0	0
Ingot bars	53	0	0
H.C. Wire rods	56	10	0
Off. av. cash, Sept.	53	0	$7\frac{37}{44}$
Do., 3 mths., Sept.	53	2	$2\frac{1}{4}$
Do., Sttlmnt., Sept.	53	1	$0\frac{24}{44}$
Do., Electro, Sept.	59	12	$7\frac{4}{11}$
Do., B.S., Sept.	60	0	$7\frac{1}{2}$
Do., wire bars, Sept.	60	5	$10\frac{10}{11}$

Solid drawn tubes 13½d.
Brazed tubes 13½d.
Wire 9¼d.

BRASS

Solid drawn tubes 12d.
Brazed tubes 14d.
Rods, drawn 10d.
Rods, extd. or rlld. 7½d.
Sheets to 10 w.g. 9½d.
Wire 9¼d.
Rolled metal 9d.
Yellow metal rods 7⅞d.

TIN

	£	s.	d.
Standard cash	233	5	0
Three months	232	0	0
English	233	5	0
Bars	235	5	0
Straits	238	5	0
Eastern	241	5	0
Banca (nom.)			—
Off. av. cash, Sept.	259	2	$2\frac{13}{22}$
Do., 3 mths., Sept.	258	1	$9\frac{21}{22}$
Do., Sttlmt., Sept.	259	1	$8\frac{5}{11}$

SPELTER

	£	s.	d.
Ordinary	17	12	6
Remelted	18	2	6
Hard	15	12	6
Electro, 99.9	21	5	0
English	18	12	6
India	16	12	6
Zinc dust	29	0	6
Zinc ashes	7	17	6
Off. aver., Sept.	21	10	$1\frac{47}{88}$
Aver., spot, Sept.	21	8	$1\frac{1}{2}$

LEAD

	£	s.	d.
Soft foreign, ppt.	17	16	3
Empire (nom.)	20	1	3
English	20	0	0
Off. aver., Sept.	21	0	$4\frac{1}{11}$
Aver. spot, Sept.	20	19	$9\frac{27}{44}$

ALUMINIUM

Ingots £100 to £105
Wire 1/3 to 1/4 lb.
Sheet and foil 1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.		£	s.	d.
Zinc sheets, English	33	10	0	to 34	0	0	
Do., V.M. ex-whse.	33	10	0	to 34	0	0	
Rods				28	0	0	

ANTIMONY

	£	s.	d.		£	s.	d.
English	92	10	0	to 93	10	0	
Chinese, ex-whse. (nom.)				82	0	0	
Crude, c.i.f.				44	0	0	

QUICKSILVER

Quicksilver 13 5 3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—
25% £14 10 0
45/50% £12 0 0
75% £17 0 0
Ferro-vanadium
35/50% 12/8 lb. Va.
Ferro-molybdenum—
70/75% carbon-free 4/9 lb. Mo.
Ferro-titanium—
20/25% carbon-free 9d. lb.
Ferro-phosphorus, 20/25% £21 to £22
Ferro-tungsten—
80/85% 9/3 lb.
Tungsten metal powder—
98/99% 9/6 lb.
Ferro-chrome—
2/4% car. 34 15 0
4/6% car. 24 5 0
6/8% car. 24 0 0
8/10% car. 24 0 0
Ferro-chrome—
Max. 2% car. 36 0 0
Max. 1% car. 38 5 0
Max. 0.5% car. 41 0 0
70% carbon-free 10d. lb.
Nickel—99.5/100% £180 to £185
"F" nickel shot £165 0 0
Ferro-cobalt, 98/99% 8/6 to 8/9 lb.
Metallic chromium—
96/98% 2/5 lb.
Ferro-manganese—
76/80% loose £18 15 0 to 19 5 0
76/80% packed £19 15 0 to 20 5 0
76/80% export £22 0 0
Metallic manganese—
94/96% carbon-free 1/3 lb.
Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten 3s. 10d.
Finished bars, 18% tungsten 5s. 0d.
Per lb. net, d/d buyers' works.
Extras—
Rounds and squares, 3 in. and over 4d. lb.
Rounds and squares, under ½ in. to ¼ in. 3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in. 1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in. 3d. lb.
Do., under ½ in. × ¼ in. 1/- lb.
Bevels of approved sizes and sections 6d. lb.
Bars cut to length, 10% extra.

SCRAP

South Wales (West)	£	s.	d.		£	s.	d.
Heavy steel, best	3	7	6	to 3	10	0	
Mixed iron and steel	3	5	0	to 3	7	6	
Heavy cast iron	3	7	6	to 3	10	0	
Good machinery	3	17	6	to 4	0	0	

Cleveland—							
Heavy steel, best	3	6	6	to 3	9	0	
Steel turnings				2	15	0	
Heavy cast iron				4	5	0	
Heavy machinery				4	10	0	

Midlands—							
Short heavy steel	3	17	6	to 4	0	0	
Light cast-iron scrap	3	2	6	to 3	5	0	
Heavy wrought iron	4	0	0	to 4	5	0	
Steel turnings				2	5	0	

Scotland—							
Heavy steel, best	3	4	6	to 3	7	0	
Ordinary cast iron	4	7	6	to 4	10	0	
Cast-iron borings	2	0	0	to 2	2	6	
Wrot-iron piling				4	17	6	
Heavy machinery	4	15	0	to 4	17	6	

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	39	0	0
Brass	25	0	0
Lead (less usual draft)	17	0	0
Tea lead	12	10	0
Zinc	12	0	0
New aluminium cuttings	71	0	0
Braziery copper	36	0	0
Gunmetal	41	0	0
Hollow pewter	155	0	0
Shaped black pewter	120	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—
Foundry No. 1 103/6
,, No. 3 101/-
,, No. 4 100/-
Forge No. 4 100/-
Hematite No. 1 123/-*
Hematite M/Nos. 122/6*

N.W. Coast—
Hem. M/Nos. d/d Glas. 123/-*
,, d/d Birm. 134/6*
Malleable iron d/d Birm. 160/-

Midlands (d/d Birmingham dist.)—
Staffs No. 4 forge 103/-
,, No. 3 fdry. 106/-
Northants forge 100/6
,, fdry. No. 3 103/6
,, fdry. No. 1 106/6
Derbyshire forge 103/-
,, fdry. No. 3 106/-
,, fdry. No. 1 109/-

Scotland—
Foundry, No. 1, f.o.t. 120/6
,, No. 3, f.o.t. 118/-
Cleveland No. 3, Glasgow 107/-
,, Falkirk 104/-
Scottish hem. M/Nos. d/d 123/-*

Sheffield (d/d district)—
Derby forge 100/6
,, fdry. No. 3 103/6
Lincs forge 106/6
,, fdry. No. 3 103/6
W.C. hematite 128/6*

Lancashire (d/d eq. Man.)—
Derby fdry, No. 3 109/-
Staffs fdry. No. 3 109/-
Northants fdry. No. 3 107/6
Cleveland fdry. No. 3 109/-
Glengarnock, No. 3 140/-
Clyde, No. 3 140/-
Monkland, No. 3 140/-
Summerlee, No. 3 140/-
Eglinton, No. 3 140/-
Gartsherrie, No. 3 140/-
Shotts, No. 3 140/-

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)	13	5	0	to 13	15	0	
Nut and bolt iron	11	12	6	to 12	2	6	
Hoops				14	2	6	
Marked bars (Staffs) f.o.t.				15	15	0	
Gas strip				14	2	6	
Bolts and nuts, ¾ in. × 4 in.				17	10	0 and up.	

Steel—							
Plates, ship, etc.	11	8	0	to 11	10	6	
Boiler plts.	11	18	0	to 12	0	6	
Chequer plts.				13	0	6	
Angles				11	0	6	
Tees				12	0	6	
Joists				11	0	6	
Rounds and squares, 3 in. to 5½ in.				12	0	6	
Rounds under 3 in. to ⅝ in. (Untested)				11	9	0	
Flats—8 in. wide and over				11	5	6	
,, under 8 in. and over 5 in.				11	10	6	
Rails, heavy				10	2	6	
Fishplates				14	2	6	
Hoops (Staffs)				12	4	0	
Black sheets, 24g. (4-t. lots)				15	15	0	
Galv. cor. shts. (,,)				19	10	0	
Galv. flat shts. (,,)				20	0	0	
Galv. fencing wire, 8g. plain				20	5	0	
Billets, soft, 100-ton lots				7	17	6	
Sheet bars				7	15	0	
Tin bars				7	15	0	

PHOSPHOR BRONZE

	Per lb. basis
Strip	12¼d.
Sheet to 10 w.g.	12⅜d.
Wire	14¼d.
Rods	14¼d.
Tubes	19¼d.
Castings	16d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry 42/6
,, furnace 37/6
Durham foundry 38/6
,, furnace 37/6
Scottish foundry 42/6
,, furnace 40/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14	per box	25/6 to 26/-
,,	28×20	,,	51/- to 52/-
,,	20×10	,,	36/6 to 36/9
,,	18¾×14	,,	26/3 to 26/6
C.W.	20×14	,,	22/6 to 23/-
,,	28×20	,,	46/- to 46/6
,,	20×10	,,	32/- to 32/6
,,	18¾×14	,,	23/- to 23/6

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.		£	s.	d.
Pig-iron	£12	0	0	to £13	0	0	
Bars-hammered, basis	£20	0	0	to £22	0	0	
Bars and nail-rods, rolled, basis	£19	0	0	to £20	0	0	
Blooms	£16	0	0	to £17	0	0	
Keg steel	£30	0	0	to £35	0	0	
Faggot steel	£20	0	0	to £25	0	0	
Bars and rods dead soft st'l	£19	0	0	to £20	0	0	

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.	
Sept. 30	..	47	5	0	dec. 10/–
Oct. 1	..	48	18	9	inc. 33/9
,, 4	..	50	2	6	,, 23/9
,, 5	..	48	12	6	dec. 30/–
,, 6	..	45	12	6	,, 60/–

Electrolytic Copper

		£	s.	d.	
Sept. 30	..	53	0	0	No change
Oct. 1	..	54	0	0	inc. 20/–
,, 4	..	55	0	0	,, 20/–
,, 5	..	54	0	0	dec. 20/–
,, 6	..	52	0	0	,, 40/–

Standard Tin (cash)

		£	s.	d.		
Sept. 30	..	244	10	0	dec.	30/–
Oct. 1	..	242	15	0	,,	35/–
,, 4	..	250	0	0	inc.	145/–
,, 5	..	242	10	0	dec.	150/–
,, 6	..	233	5	0	,,	185/–

Tin (English ingots)

		£	s.	d.		
Sept. 30	..	244	10	0	dec.	30/–
Oct. 1	..	242	15	0	,,	35/–
,, 4	..	250	0	0	inc.	145/–
,, 5	..	242	10	0	dec.	150/–
,, 6	..	233	5	0	,,	185/–

Spelter (ordinary)

		£	s.	d.		
Sept. 30	..	19	0	0	dec.	2/6
Oct. 1	..	19	5	0	inc.	5/–
,, 4	..	19	16	3	,,	11/3
,, 5	..	19	0	0	dec.	16/3
,, 6	..	17	12	6	,,	27/6

Spelter (Electro, 99.9 per cent.)

		£	s.	d.		
Sept. 30	..	22	11	3	inc.	6/3
Oct. 1	..	22	18	9	,,	7/6
,, 4	..	23	10	0	,,	11/3
,, 5	..	22	12	6	dec.	17/6
,, 6	..	21	5	0	,,	27/6

Lead (soft foreign, prompt)

		£	s	d.		
Sept. 30	..	19	3	9	dec.	5/–
Oct. 1	..	19	3	9	No change	
,, 4	..	19	11	3	inc.	7/6
,, 5	..	19	3	9	dec.	7/6
,, 6	..	17	16	3	,,	27/6

Lead (English)

		£	s.	d.		
Sept. 30	..	21	5	0	dec.	5/–
Oct. 1	..	21	5	0	No change	
,, 4	..	21	15	0	inc.	10/–
,, 5	..	21	5	0	dec.	10/–
,, 6	..	20	0	0	,,	25/–

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1902	7 0 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 12 4
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4½
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11½
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 16 0	5 15 0	6 0 0	6 0 0	6 5 0	6 15 0	6 1 10	
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0½
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 9
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0½
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0½
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5½
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 18 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6
1936 .. *	9 12 6	9 15 0	10 2 6	10 2 6	10 2 6	10 2 6	10 6 3	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 5½
1937	10 10 0	10 10 0	11 17 6	11 17 6	11 17 6	11 17 6	12 4 6	13 5 0	13 5 0	—	—	—	—

* No quotation available owing to strike.

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7. Applications, giving date of birth, particulars of qualifications and experience, and accompanied by copies of testimonials, should be forwarded to the Secretary of the Admiralty (C.E. Branch) not later than October 23, 1937, quoting Reference Number C.E.7851/37.

8. No application forms are required.

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